THE
BRITISH JOURNAL OF SURGERY

VOL. X. JANUARY, 1923. No. 39.

EPONYMS.

BY SIR D'ARCY POWER, K.B.E., LONDON.

VII. PERCIVALL POTT: HIS OWN FRACTURE.

PERCIVALL POTT ranks high amongst the surgeons of the eighteenth century. He was a sound teacher of clinical surgery when the organized teaching of medical students had hardly yet begun. Samuel Sharp, of Guy's, was before him in point of time, but Sharp taught those who were already in practice: "He gave", says the historian, "a course of anatomical lectures to which were added the operations of surgery, with the application of bandages, to a Society of Naval Surgeons which met in Covent Garden on winter evenings." This course he repeated for several years, and when attacks of asthma caused him to discontinue it, the school was carried on by William Hunter, who taught surgery as a branch of anatomy.

Edward Nourse, to whom Pott was apprenticed, gave occasional lectures to the students at St. Bartholomew's Hospital, but they dealt rather with the principles than the clinical aspects of surgery, and were of a purely formal character, if we may judge from the syllabus of his lectures on anatomy which is still extant.

Pott took the modern line. Attached to a large hospital where there was plenty of clinical material, he used his opportunities by telling students of the mistakes he had made, of the cures he had done, and of the cases he had seen. He was necessarily ignorant of surgical pathology, for it was born of John Hunter, who attended some of these lectures as his pupil. It is curious to observe in reading Pott's treatises how largely this ignorance vitiated his conclusions and paralyzed his treatment. We must think of him, therefore, as a surgeon of the old school, as superior to Wiseman as Wiseman was to Woodall; but in every respect inferior to John Hunter, who was a thinker as well as an observer. Nevertheless Pott's sound common sense, his transparent honesty of purpose, his desire to teach what he knew, and his position as surgeon to a large hospital, made him a great leader in surgery, whilst the success of his lectures and his pleasant manner of writing spread his teaching widely and made his name known throughout France and Germany.

Percivall Pott was born in London, the son of a scrivener who died when he was three years old, leaving his mother so poor that after his death a small box was found which contained less than five pounds, the whole sum received from the wreck of his father's fortune. His mother, however, was well connected; her first husband had been a Houblon, and the Houblons were merchant strangers under Elizabeth, Roundheads under the Commonwealth, Whigs and founders of the Bank of England under William III. His upbringing was easy, therefore, and in 1729 he was bound apprentice to Edward Nourse, then Assistant Surgeon to St. Bartholomew's Hospital, paying two hundred

guineas for his indentures. He appears to have acquired a reputation unusually early, for during the later years of his apprenticeship it is recorded that, " being confident in the fair prospect of industry, he hired a house of considerable size in Fenchurch Street and took with him his mother " and his step-sister. The venture was successful, for at the end of his apprenticeship in 1736 he was made free of the Barber Surgeons' Company, and there is an unusual entry in the minute books of the Company about him. It states that " At a meeting of the Court of Examiners on September 7, 1736, the Question being put whether Mr. Percival Pott should be examined at this Court, he not having waited on all the Governors and Examiners to desire the favour of their presence at his examination, and it appearing to the Court that Mr. Pott had been sent for out of Town to attend Sir Robert Goodesall's* Lady where he was detained so long as not to be able to return within the time limitted for his attendance on the Governors and Examiners, and Mr. warden Petty having been pleased to say that he would make his excuse to the Court ; It was resolved that the Court would proceed to the Examination of the said Mr. Pott notwithstanding his default in attending the Examiners ; but this is not to be a precedent in time to come to any other person ;—And then

" The said Mr. Percivall Pott was examined touching his skill in surgery in order to have the Great Diploma, his answers were approved, and he was ordered a Diploma under the seal of the Company and the hands of the Governors testifying his skill and Impowering him to practise."

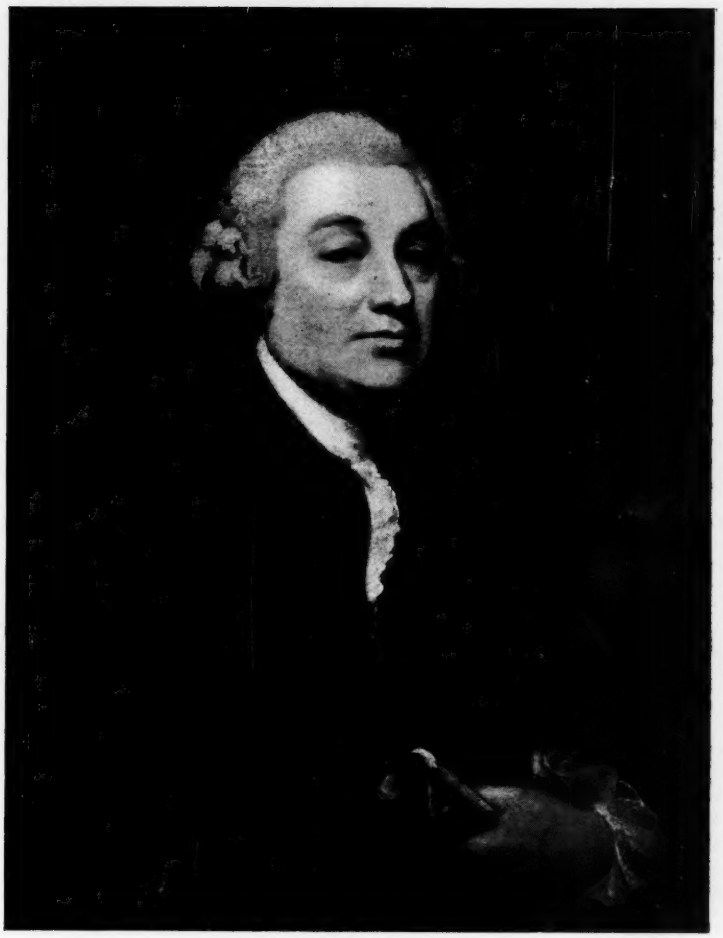
This minute is interesting from many points of view. It shows that he had already determined to practise pure surgery, as the Great Diploma corresponded in some measure to the present F.R.C.S. It was rarely given, and only after a very thorough examination. It raises the suspicion, too, that he was practising midwifery at this time, which he would be entitled to do if he chose, as neither the College of Physicians, the Company of Barber Surgeons, nor the Universities of Oxford or Cambridge, claimed any control over a man-midwife. It shows, too, that Pott was already esteemed by the Barber Surgeons' Company, for so old and well-established a custom as the personal visit to the examiners would not otherwise have been waived.

Pott was a devoted son, and so long as his mother lived he made a home for her, and it was not until after her death that he married Sarah Cruttenden, by whom he had five sons and four daughters. He then moved into a house in Watling Street, where he began the course of surgical lectures which made him famous. He was elected Assistant Surgeon to St. Bartholomew's Hospital in 1744, becoming full surgeon in 1749.

In 1756 an accident befell him which—by a curious confusion of thought—made his name of world-wide fame. " As he was riding in Kent-street, Southwark ", says Sir James Earle, his son-in-law, successor, and biographer, " he was thrown from his horse, and suffered a compound fracture of the leg, the bone being forced through the integuments. Conscious of the dangers attendant on fractures of this nature, and thoroughly aware how much they may be increased by rough treatment, or improper position, he would not suffer himself to be moved until he had made the necessary dispositions. He sent to Westminster, then the nearest place, for two chairmen, to bring their poles ; and patiently lay on the cold pavement, it being the middle of January, till they arrived. In this situation he purchased a door, to which he made them nail their poles. When all was ready, he caused himself to be laid on it, and was carried through Southwark, over London-bridge, to Watling-Street, near St. Paul's, where he had lived for some time—a tremendous distance in such a state ! I cannot forbear remarking, that on such occasions a coach is too frequently employed, the jolting motion of which, with the unavoidable awkwardness of position, and the difficulty of getting in and out, cause a great and often a fatal aggravation of the mischief. At a consultation of surgeons, the case was thought

---

* Robert Goodschall, Alderman of Bishopsgate Ward and Sheriff of London, received the honour of Knighthood at St. James's Palace on Oct. 31, 1735, on the occasion of an address congratulating King George II on his safe return from Hanover. Goodschall was afterwards M.P. for the City of London. He died in 1742 whilst holding the office of Lord Mayor. Lady Goodschall died Sept. 27, 1755.



PERCIVALL POTT

1714 - 1788

Copied by permission from the painting by George Romney in the Council Room of the Royal College of Surgeons of England

so desperate as to require immediate amputation. Mr. Pott, convinced that no one could be a proper judge in his own case, submitted to their opinion; and the instruments were actually got ready, when Mr. Nourse, who had been prevented from coming sooner, fortunately entered the room. After examining the limb, he conceived there was a possibility of preserving it: an attempt to save it was acquiesced in, and succeeded. This case, which Mr. Pott sometimes referred to, was a strong instance of the great advantage of preventing the insinuation of air into the wound of a compound fracture; and it probably would not have ended so happily, if the bone had not made its exit, or external opening, at a distance from the fracture; so that, when it was returned into the proper place, a sort of valve was formed, which excluded air. Thus no bad symptom ensued, but the wound healed, in some measure, by the first intention.—The appearance of Mr. Pott as an author was an immediate effect of this accident". It is clear from this account that the accident which Pott sustained was an open fracture of the tibia—spiral or very oblique—and that the nib-shaped end of the upper fragment penetrated the skin.

Pott's fracture, as it is now known, he described carefully in his *Remarks upon Fractures and Dislocations*, published in 1768 without any reference to his own case. The desperate nature of the prognosis in cases of compound fracture as it was then treated is well exemplified by Pott in this treatise. He wrote, "When a surgeon says that a limb, which has just suffered a particular kind of compound fracture, ought rather to be immediately cut off, than that any attempt should be made for its preservation, he does not mean, by so saying, that it is absolutely impossible for such limb to be preserved; at all events he is not to be supposed to mean so much in general, though sometimes even that will be obvious; all that he can truly and justly mean is, that from the experience of all time it has been found, that the attempts to preserve limbs so circumstanced, have most frequently been frustrated by the death of the patients, in consequence of such injury; and that from the same experience it has been found, that the chance of death from amputation is by no means equal to that arising from such kind of fracture."

This passage gives a good example both of Pott's literary style and of the sound common sense with which he was endowed. He resigned his office of Surgeon to St. Bartholomew's Hospital in 1787, after having served the charity, as he used to say, man and boy for half a century. He died of pneumonia on December 22, 1788, and was buried in the chancel of St. Mary's, Aldermary, in Queen Victoria Street, where a tablet to his memory may still be seen on the wall of the south aisle. His kindness of heart was proverbial, and although he had a large family dependent upon him, it is said that, at one time, he had three needy surgeons living in his house until he could provide them with the means of earning an independent livelihood. His high character and blameless life helped to raise the surgeon's social standard in this country.

The portrait is copied by permission from that in the Council Room of the Royal College of Surgeons of England. It was painted by George Romney, and was presented to the College by the Ven. Archdeacon J. H. Pott. The College also possesses a life-size half-length portrait painted by Sir Nathaniel Dance Holland, Bt., R.A., and there is the well-known picture by Sir Joshua Reynolds, which hangs in the Great Hall at St. Bartholomew's Hospital.

ABNORMALITIES OF THE DUODENUM.

By JOHN H. ANDERSON, C.M.G., C.B.E., Melbourne.

Arising from certain remarks made by a Melbourne clinician, a routine examination was made of 100 consecutive subjects presenting in the Anatomy Department of the University of Melbourne, with a view to noting any cases of gross abnormality in the shape or position of the duodenum. As a result of this examination four cases of gross abnormality were discovered, which may be classified as follows :—

Case 1.—Abnormal shape.
„ 2.—Constriction caused by the superior mesenteric artery.
„ 3.— „ „ „ an annular pancreas.
„ 4.—Abnormal position.

General Consideration of the Cases Presenting Abnormality.—

Preservative.—All cases had been formalin hardened.

Cause of Death.—This varied from cardiac failure to senile decay, but in no case had it any apparent connection with the abnormality present.

Sex Incidence.—All cases occurred in males.

Age Incidence.—All cases were in old people, the ages ranging from 65 to 74 years.

Clinical History.—The sources from which the material for a dissecting-room is gathered make the collection of medical histories a matter of some difficulty. From what was available, however, the interesting fact emerged that the duodenal abnormalities had not given rise to any acute trouble during the later years of life. The age of the subjects and the absence of signs of operative interference would tend to support this observation.

The Normal Duodenum.—The description of the duodenum as set out in Berry's *Practical Anatomy*[1] and Gray's *Anatomy*[2] has been taken as a criterion for comparison and is regarded as presenting the normal state of affairs.

PARTICULARS OF CASES.

Case 1.—**Abnormal Shape.**

General Description.—The duodenum consisted of four parts, superior, descending, ascending, and horizontal, in that order. The superior or first part was normal, and passed directly into a second or descending part, which after a caudal course of 6 cm. terminated in an acute bend cranially and to the right, with a slight dorsal inclination, so that the left margin of the ascending part was overlapped by the right margin of the adjacent descending part. The ascending part, after a course of 5 cm., turned to the left at an angle of 90° and passed dorsal to the descending part, thus forming the commencement of the fourth or horizontal part, which after a straight course of 12 cm. terminated in the usual manner, though slightly more cranial than normal. The diameter of the bowel was within normal limits throughout.

Relations.—The ascending part lay ventral to the caudal pole of the right kidney, and was in close contact with the hilus of the same viscus. The pancreas lay cranial to the horizontal part, and though no head could be defined, an uncinate process was distinctly visible. The superior mesenteric vessels were normal, and passed ventral to the horizontal part of the bowel. The common bile-duct and the main duct of the pancreas united in the substance of the latter viscus, and the resulting single duct passed ventral

to the horizontal part of the duodenum to open into the lumen of the bowel on the dorsal aspect of the acute flexure caused by the union of the descending and ascending parts of the duodenum. These points are well seen in the diagram attached (*Fig.* 254), which is about one quarter life size and was constructed from actual photographs.

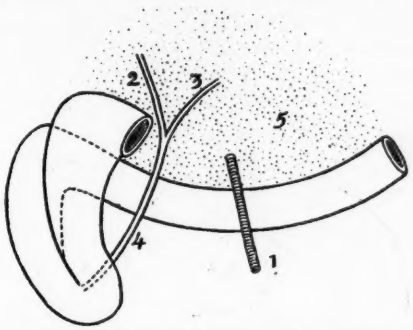


Fig. 254.—*Case* 1. (1) Superior mesenteric artery. (2) Common bile-duct. (3) Main pancreatic duct. (4) Combined bile and pancreatic duct. (5) Pancreas.

REMARKS.—Piersol[3] states, "much variation exists in the shape of the duodenum", and thinks this may be due "to an unusually long duodenum, which, after having completed the usual course, describes one or more additional curves before reaching the duodenojejunal flexure". Such would not appear to be the cause in this case, where the whole duodenum presented a normal length of 25 cm., and where the operating cause would appear to be a kink taking place during rotation. A careful search of available literature has failed to reveal an absolutely similar case, though that described by Schiefferdecker,[4] and quoted and illustrated by Piersol,[3] is a near approach. The position of the conjoined duct formed by the union of the common bile-duct and the main duct of the pancreas is a point of some clinical importance.

Case 2.—**Constriction caused by Superior Mesenteric Artery.**

GENERAL DESCRIPTION.—In five cases of the hundred examined there was some 'flattening' observed at the point where the superior mesenteric vessels crossed the horizontal part of the duodenum, and in one other case a definite constriction was noticed at the same point. In this last case the duodenum was normal elsewhere as regards length and diameter, and there was no "chronic dilatation of the first three parts" as described by Wilkie.[5] The constriction was an annular one, the outside diameter being 0·9 cm. On opening the bowel it was found that a slate pencil would pass freely through the lumen of the constriction, but a lead pencil required some force to push it through, and caused an increase in the outside diameter. The peritoneum over the constriction was particularly smooth and shiny, and "looked worn", and there was an absence of any puckering. Macroscopic examination of the constriction, after longitudinal section, failed to show any abnormality in the bowel wall, nor could any trace of ulcer be found in stomach or duodenum. The stomach was not dilated, and the superior mesenteric artery, in common with other abdominal contents, appeared normal.

REMARKS.—The interest of this case lies in its presence in a male, the absence of gastric or duodenal ulcer, the absence of gastric or duodenal dilatation, and, as far as can be ascertained, the absence of clinical disturbance.

Bearing in mind the danger of drawing conclusions from a single example (and that a formalin-hardened dissecting-room subject), it would appear from the cases put forward by Wilkie[5] and Devine[6] that three grades of this type may be described :—

Grade I.—Constriction, without duodenal dilatation and without clinical signs.

Grade II.—Constriction, with moderate duodenal dilatation and perhaps ulcer (gastric or duodenal), and with clinical signs of a chronic nature.

Grade III.—Constriction, with excessive duodenal dilatation, and with clinical signs of an acute nature, mainly those of obstruction.

Case 3.—**Constriction caused by Annular Pancreas.** (*Figs.* 255, 256, 257, 258.)

GENERAL DESCRIPTION.—A complete ring of pancreatic tissue surrounded the descending part of the duodenum, causing a very definite constriction. The greatest diameter of this ring, which was flattened in the ventrodorsal direction, was 2·5 cm. and the smallest diameter was 1·8 cm. The rest of the pancreas was normal. The first part of the duodenum could not be defined as such, but between the pylorus and the duodenal

constriction was a dilated portion of bowel 4·7 cm. long and 4·8 cm. in diameter. The constriction itself had an outside diameter of 1·2 cm. and would admit a lead pencil through its lumen. Below the constriction the duodenum had a diameter of 3·5 cm., and the total length of first and second parts combined was 10·5 cm. Opposite the crossing point of the mesenteric vessels the diameter fell to 2·6 cm., swelling out to 3·5 cm. just proximal to the duodenojejunal flexure. The total length of the whole duodenum was 25·5 cm.

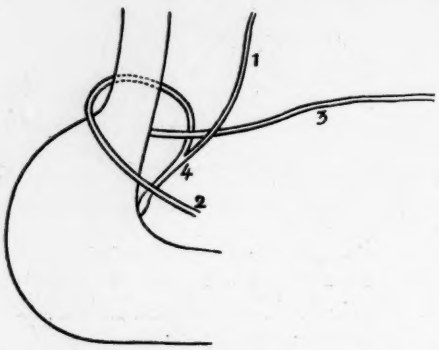


Fig. 255.—*Case* 3. (1) Common bile-duct. (2) Main pancreatic duct, annular in form. (3) Large accessory pancreatic duct. (4) Junction of bile and pancreatic ducts.

Arrangement of Ducts.—The main pancreatic duct started in the caudal part of the head of the pancreas, and passed to the right, completely encircling the duodenum in the ring of pancreatic tissue. It then joined the common bile-duct, and opened into the bowel below the constriction and on its medial side. The remainder of the pancreas was drained by an accessory duct, very well developed, which opened into the bowel below the constriction and 2 cm. cranial to the opening of the conjoined duct above described. This arrangement of the ducts is shown in ***Fig.*** 255 (not drawn to scale).

REMARKS.—Annular pancreas is sufficiently rare to deserve some special consideration. A careful search of the available literature has revealed fourteen cases, some of which are summarized in the following table.

CASES OF ANNULAR PANCREAS.

AUTHOR	SEX	PART OF DUODENUM	STATE AT RING	STATE ABOVE RING	STATE OF STOMACH	DUCT IN RING
Ecker[7] ..	M.	Second	Constricted	Dilated	——	Opens into main duct
Auberg[8] ..	M.	Fourth	Constricted	——	——	——
Symington[9]	M.	Second	Constricted	Dilated	Normal	——
Genersich[8]	M.	Second	Constricted	Dilated	Dilated	Opens into main duct
Sandras[8] ..	M.	Second	Constricted	Dilated	——	——
Tieken ..	M.	Second	Constricted	Dilated	Dilated and hypertrophied walls	Normal
Baldwin[8] ..	—	Second	Constricted	Dilated	Normal	Opens into main duct
Cords[11] ..	M.	Second	Constricted	——	——	One opening main duct, one opening separately
Anderson ..	M.	Second	Constricted	Dilated	Dilated	Forms the main duct

Cases of annular pancreas are also reported by the following, but full particulars are not available in Melbourne: Summa,[8] Thacher,[8] Lecco[10] (two cases), Bécourt,[15] and Moyse.[15] Piersol,[3] Quain,[12] Cunningham,[13] Poirier and Charpy,[7] and Morris,[14] among the text-books of anatomy, also refer to this "most interesting but rare variation".

Mode of Causation.—This matter is fully discussed by Baldwin,[8] Lecco,[16] and Cords.[11] Baldwin's explanation (which seems fully borne out by the arrangement of the ducts) may be shortly stated as follows. The pancreas arises from the duodenal wall by two *Anlagen,* one ventral and one dorsal. The former consists of two parts, a left and a right.

The right half is carried round to the right and then dorsal to the duodenum during the rotation of the latter, and, after fusion with the dorsal *Anlage*, forms the caudal segment of the head of the pancreas. In it is developed the main pancreatic duct. The left half of the ventral *Anlage* generally atrophies. If it persists and extends to the left, ventral to the duodenum, to join the main mass of pancreatic tissue, or if there is an excessive growth of the right half of the same *Anlage*, in a like direction, annular pancreas results.

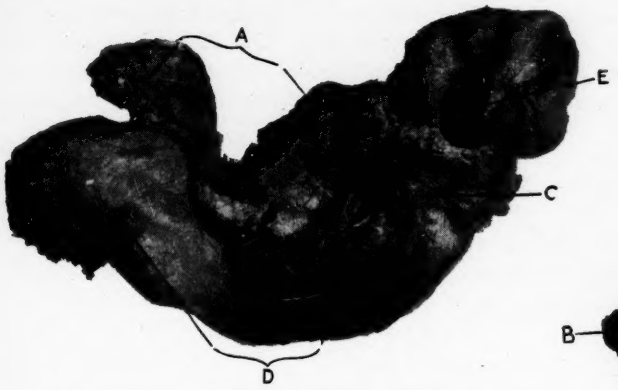


Fig. 256.—*Case* 3. Pancreas and duodenum, dorsal view. (A) Pancreas. (C) Pancreatic ring, dorsal limb. (D) Duodenum. (E) Common bile-duct.

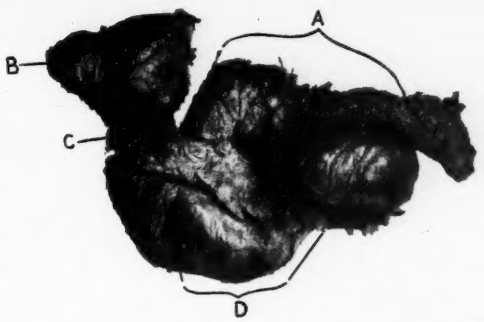


Fig. 257.—*Case* 3. Pancreas and duodenum, ventral view. (A) Pancreas. (B) Pylorus. (C) Pancreatic ring, ventral limb. (D) Duodenum.

Summary. — Annular pancreas is almost always found in males, and causes: (*a*) A constriction of the second part of the duodenum; (*b*) A dilatation of the duodenum cranial to the constriction. This dilatation may involve the stomach and may be accompanied by hypertrophy of the walls of that viscus. There is generally a well-marked duct in the ring of pancreatic tissue which joins the common bile-duct. The mode of causation of this abnormality can be readily explained on embryological grounds.

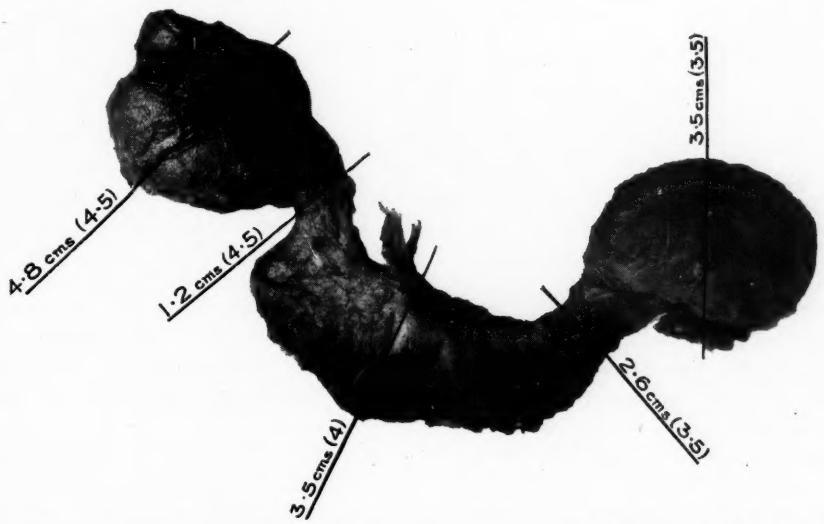


Fig. 258.—*Case* 3. Duodenum after removal of annular pancreas. To show diameter of duodenum at various points. Normal diameters shown in brackets.

Clinical Considerations.—The surgical and anatomical literature available makes no mention of a clinical picture associated with annular pancreas, and this view is

supported by Huet,[17] who states: "Le pancréas annulaire peut rester longtemps sans symptômes chez le vivant; il peut être reconnu à l'occasion d'une intervention pratiqueé par un syndrôme de retrécissement pylorique ou de pancréatite chronique". This is in great contrast to the vivid picture painted by Wilkie[5] of the possible effects of a constriction caused by the superior mesenteric vessels. The difference may lie in the comparative rarity of annular pancreas, and may be influenced by the fact that it produces a fixed constriction, not one liable to changes in calibre brought about by other abdominal variations, as would seem to be the case with a mesenteric constriction.

Case 4.—**Abnormal Position.**

General Description.—An inguinal hernia, of the type described by Hamilton Russell[18] as 'hernia magna', was present on the left side. This contained the terminal 1·5 m. of the ileum, the cæcum and appendix, part of the ascending colon, and 30 cm. of the pelvic colon. With the exception of the pelvic colon, all the bowel within the sac was attached to the peritoneum forming the dorsal wall of the sac by two well-defined mesenteries, one for small and one for large intestine. The mesentery for the ileum appeared normal both within and without the sac, but between the two layers of mesentery of the large bowel there was deposited a large amount of fat. This mesentery ceased on passing from hernial sac to abdomen proper. The right colic flexure did not exist as such, but in the right iliac fossa the bowel made a gentle curve cranially and to the left, thus marking the commencement of the transverse colon. The left colic flexure was situated 2·5 cm. caudal to the lower pole of the left kidney. The pylorus lay opposite the third lumbar vertebra, and the duodenum crossed the mid-line ventral and slightly caudal to the bifurcation of the abdominal aorta, at the level of the intervertebral disc between the fourth and fifth lumbar vertebræ. *Fig.* 259 shows roughly the position of the structures named. The liver, kidneys, and spleen were normal in position.

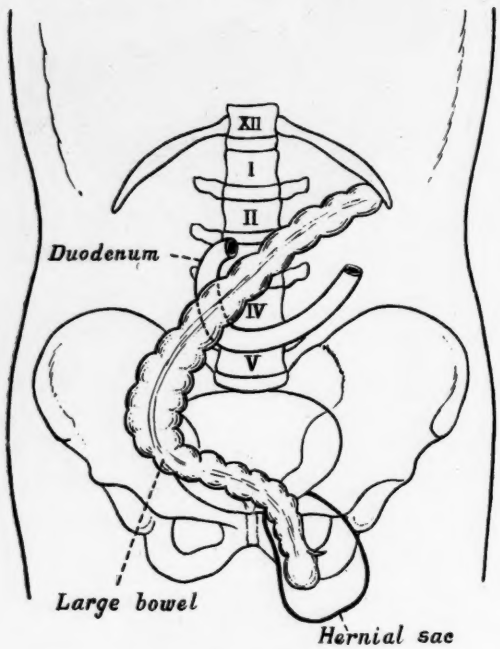


Fig. 259.—*Case* 4.

Though the number of lumbar vertebræ was normal, the distance between the tip of the xiphoid process and symphysis pubis was 8 cm. less than that observed on four other subjects of similar stature, while the tip of the last rib was almost in contact with the iliac crest on either side. The cœliac artery was 5·5 cm. in length, and was directed caudally, ventral to an abnormally broad pancreas.

Remarks.—The peritoneal attachments of bowel to the dorsal abdominal wall would appear to have slipped, or else developed in an abnormal position, with a consequent descent of the various parts of the alimentary canal within the abdomen, up to but not including the left colic flexure. This in turn would cause the abnormal length of the cœliac artery.

The suggestion is also advanced that the transference of so much bowel from the abdominal cavity to the hernial sac resulted in a lack of stimulus to longitudinal growth, which caused a reduction in the length of the long axis of the abdomen. If this supposition is correct, it has a certain bearing on operating for herniæ of this size before body growth has ceased.

GENERAL CONCLUSIONS.

In addition to the conclusions drawn with respect to the various cases described, it may be stated that :—

1. Gross anatomical abnormalities of the duodenum are more frequent than is generally supposed.

2. Such abnormalities may exist without producing any clinical evidence of their presence.

I am indebted to Mr. J. C. Eccles, Prosector in Anatomy, for his assistance in the dissecting carried out in these cases, and to Mr. W. H. Preston for his admirable photographs.

REFERENCES.

[1] R. J. A. Berry, *Practical Anatomy*, 1922, ii.
[2] Henry Gray, *Anatomy, Descriptive and Applied*, 21st ed.
[3] G. A. Piersol, *Human Anatomy*, 3rd ed.
[4] Schiefferdecker, *Arch. für Anat. und Entwicklung*, 1887.
[5] D. P. D. Wilkie, "Chronic Duodenal Ileus", *Brit. Jour. Surg.*, ix, No. 34, 204.
[6] H. B. Devine, "The Surgical Problems of the Stomach and Duodenum", *Med. Jour. of Australia*, 1921, Feb. 5 and 12.
[7] P. Poirier and A. Charpy, *Traité d'Anatomie humaine*, 1901.
[8] Wesley M. Baldwin, "A Specimen of Annular Pancreas", *Anat. Rec.*, 1910, iv, 299.
[9] J. Symington, "A Rare Abnormality of the Pancreas", *Jour. Anat. and Physiol.*, 1885, xix, 292.
[10] T. M. Lecco, "Pancreas annulare", *Wien. klin. Woch*, Jahrg. xxiii.
[11] E. Cords, "Ein Fall von ringformigem Pancreas", *Anat. Anzeiger*, 1911, xxxix, No. 2–3.
[12] Quain, *Anatomy*, 11th ed., ii, pt. 2, 150.
[13] Cunningham, *Text-book of Anatomy*, 4th ed.
[14] Morris, *Human Anatomy*, 6th ed.
[15] M. Schirmer, "Beitrag zur Geschichte und Anatomie des Pancreas", *Inaug-Diss.*, Basel, 1893, 50.
[16] T. M. Lecco, "Zum Cordsschen Fall von Pancreas annulare", *Anat. Anzeiger*, 1911, xxxix, No. 19–20.
[17] P. Huet, "Le Pancréas annulaire", *Thèse Bordeaux*, 1911, No. 113.
[18] R. Hamilton Russell, "Inguinal Herniæ: their Varieties, Modes of Origin, and Classification", *Brit. Jour. Surg.*, ix, No. 36.

LARGE MYELOID SARCOMA (MYELOMA) OF THE RADIUS IN WHICH THE TUMOUR IS WHITE THROUGHOUT.

By MATTHEW J. STEWART, Leeds.

The maroon colour of myeloid sarcoma is generally, and justifiably, held to be one of the most characteristic naked-eye features of these growths, and most surgeons would probably regard such an appearance at the time of operation as diagnostic. The dark-red or maroon colour may affect the whole tumour, or only a part of it, and it is quite usual to see considerable areas of white tissue here and there. As a rule, the latter correspond to the more fibrous portions in which giant cells are comparatively scanty, while the red parts are either very cellular areas, highly vascular, and with numerous multinucleated giant cells and many effused red blood-corpuscles, or else mere hæmorrhagic extravasations of large size. I have long been familiar, however, with the fact that some of the white portions of a myeloid sarcoma, notably those occurring at the growing margin, consist, not of densely fibrous, comparatively acellular tissue, but of highly cellular, actively proliferating myeloid tissue, with a large proportion of giant cells. It therefore seemed reasonable to regard the maroon colour as a secondary, even accidental characteristic, due partly to increased vascularity, and partly—and more especially—to extravasation of blood.

Under these circumstances, the finding of a large myeloid sarcoma which was white throughout was quite in keeping with one's preconception of the pathology of this tumour, but the rarity of the condition, as well as its theoretical importance, calls, I think, for a full and adequately illustrated case report.

While practically all the modern descriptions of myeloid sarcoma insist on the constancy of this colour characteristic, and only admit at most that *portions* of the tumour may be white, Sir James Paget,[1] in 1853, states quite unequivocally that "the tumour may be all pale. . . ." His description of the naked-eye characters of the growth is well worth quoting: "On section, the cut surfaces appear smooth, uniform, compact, shining, succulent, with a yellowish, not a creamy, fluid. A peculiar appearance is commonly given to these tumours by the cut surface presenting blotches of dark or livid crimson, or of a brownish or a brighter blood-colour, or of a pale pink or of all these tints mingled, on the greyish-white or greenish colour basis. This is the character by which, I think, they may best be recognized with the naked eye, though there are diversities in the extent, and even in the existence, of the blotching. The tumour may be all pale, or have only a few points of ruddy blotching, or the cut surface may be nearly all suffused, or even the whole substance may have a dull modena or crimson tinge, like the ruddy colour of a heart or that of the parenchyma of a spleen."

The case here recorded is a striking example of a myeloid sarcoma which is 'all pale'.

HISTORY OF CASE.

The patient, a small girl of 6 years, was admitted to the Leeds General Infirmary under the care of Mr. L. R. Braithwaite in March, 1922, suffering with a swelling of the distal half of the left forearm. This had commenced about three years before, and while it had grown slowly at first, during the last three months there had been a rapid increase in size. There was no history of injury, and there seemed to be little or no pain or discomfort. The tumour appeared to spring from the radius. It was firm, of regular, ovoid outline, and not tender on pressure. Several firm, enlarged glands were palpable in the left axilla.

An *x*-ray plate (*Fig.* 260) shows that the distal half of the diaphysis of the radius is the seat of radiolucent expansion. There is a very delicate shell of expanded bone round considerable portions of the periphery, with a number of slight trabecular thickenings on its inner aspect. On the side towards the ulna, however, the bony capsule appears to have completely disappeared.

The central part of the tumour contains no bone whatever. Proximally, there is a fairly sharp line of demarcation between the tumour and the rest of the shaft, with a certain amount of bony superficial thickening under the periosteum, just where the shaft is beginning to be expanded. Distally the tumour stops short at the line of the epiphyseal cartilage. The appearances are very strongly suggestive, if not actually pathognomonic, of myeloid sarcoma.

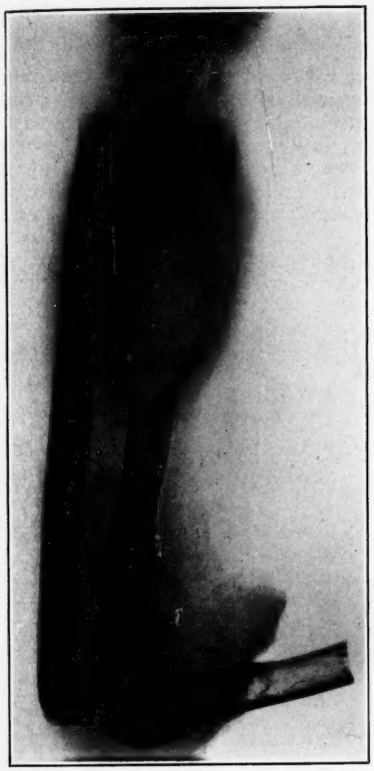


FIG. 260.—Radiograph of the specimen after removal, the arm being roughly in the same position as in *Fig.* 261. The tumour is endosteal and radiolucent, and it has caused great expansion of the shaft of the bone. A delicate shell of bone, with trabecular markings, is seen on the upper (radial) aspect of the growth, but on the side towards the ulna this capsule has completely disappeared.

On March 24 a small portion of the tumour was excised for microscopic examination. It was white in colour, and not at all like the usual appearance of a myeloid sarcoma, yet the microscopic characters were quite unmistakable (*Fig.* 262). In particular, osteoclast-like giant cells were found in the greatest profusion, constituting, in some fields, more than half the total area. At the point where the portion of growth was excised, there was no bony capsule whatever; the tumour was directly invading the surrounding muscle and other soft parts.

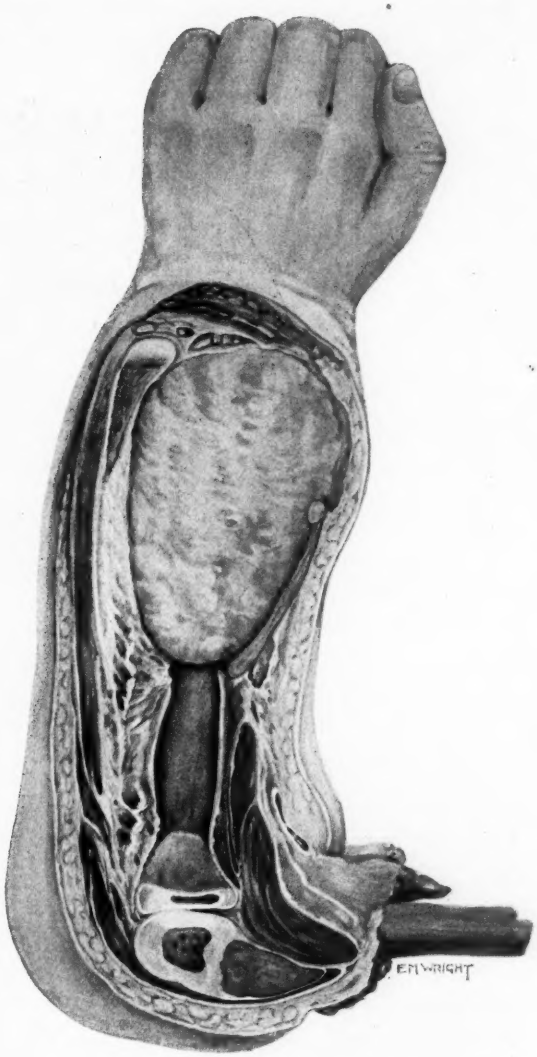


FIG. 261.—Myeloid sarcoma of the distal half of the left radius, shown on anteroposterior section, after amputation of the arm. The tumour is white throughout, and shows neither gross necrosis, hæmorrhage, nor cystic change.

(*Drawing by Miss Ethel Wright.*)

After careful consideration, it was decided that the case should be treated by amputation, mainly on account of the radiological and histological evidence of extensive involvement of soft tissues.

On April 4 the arm was amputated by Mr. Braithwaite through the lower third of the humerus. The axillary glands were not touched, as the patient was rather shocked by the main operation. Recovery was uninterrupted, and when the patient was discharged from hospital it was observed that the axillary glands were no longer palpable.

A longitudinal section through the forearm, with the limb in the midway position between supination and pronation (*Fig.* 261), shows the distal half of the radius to be replaced by a large, solid, pyriform tumour, measuring 2½ in. long by 1½ in. broad. Its cut surface is pale

throughout, being to all intents and purposes white, with a few small yellowish patches here and there, and two greyish, slightly translucent areas near the centre. It is fairly sharply outlined at the margin, but shows evidence of infiltration of the surrounding tissues. On its radial side it has caused great pressure on the muscles, which are thinned out and pale in consequence. It has also partially surrounded one of the flexor tendons, which lies in a deep groove in the growth. On the opposite side the tumour is in direct contact with the lower half of the ulna, which is slightly distorted in consequence.

HISTOLOGY (*Fig.* 262).—The microscopic structure is that of a typical myeloid sarcoma, but without the usual areas of congestion and hæmorrhage. The preponderating tissue consists of a mixed- and spindle-cell ground-work, with innumerable multinucleated giant cells of osteoclast type. Scattered throughout this are many small, comparatively acellular areas of dense fibrous tissue, containing few or no giant cells. The two centrally situated greyish, translucent areas mentioned in the naked-eye description consist solely of fibrous tissue: cellular around the vessels; mucoid, comparatively acellular, and in parts even necrotic, away from them. In these fibrous areas, only an occasional small, shrunken giant cell is seen. Undoubtedly the most cellular portions of the tumour are at the periphery, and it is here that the giant cells are, if anything, most abundant. In the highly cellular areas, the mixed-cell ground-work of the tumour

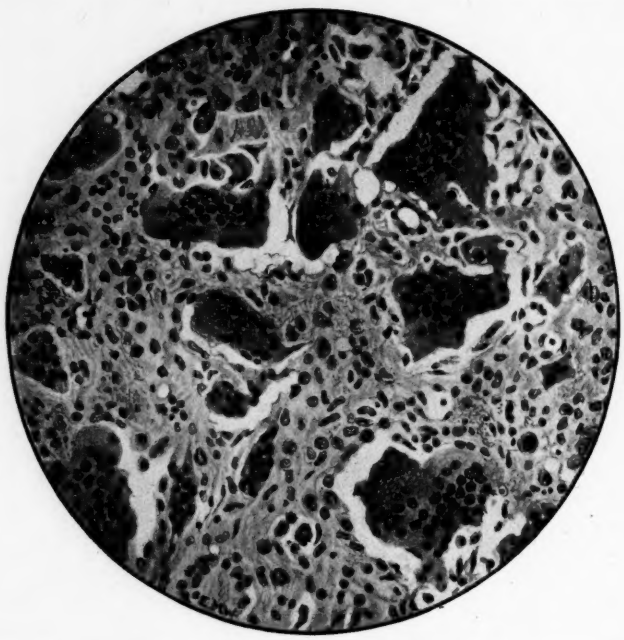


FIG. 262.—Drawing of a typical portion of the tumour showing a mixed-cell stroma and many large osteoclast-like giant cells. (*Miss Ethel Wright.*)

is in a state of active proliferation, mitotic figures being present in abundance. Both cells and nuclei vary greatly in size and shape, and the whole appearance is that of a mixed-cell (preponderatingly spindle-cell) sarcoma.

The giant cells have very numerous, small, uniform nuclei, usually centrally situated and often arranged in a whorl. They do not show any mitotic figures. The cytoplasm is homogeneous or granular, and stains more deeply than that of the other cells.

Over extensive areas of the surface of the tumour the bony shell has been completely destroyed. Occasionally a tiny spicule of bone is seen embedded in the growth; otherwise there is no evidence of ossification. Wherever the bony covering is lacking, infiltration of the surrounding soft tissues, muscle, adipose tissue, etc., may be seen, and in places there are appearances suggestive of penetration of blood-vessels by the giant cells.

The chief interest of this case lies in the colour of the growth. Sarcomas of bone, whether endosteal or periosteal, which are white in colour, are almost invariably highly malignant, and most surgeons, on finding such a tumour at operation, would probably be prepared to amputate forthwith. Amputation was carried out in the present instance, not because of any doubt on the part of the surgeon as to the comparatively benign nature

of the growth, but on account of the fact that the tumour had completely burst its bony capsule over a large area, and was actively invading the surrounding soft parts. In spite of its large size and highly cellular character, the growth is white and succulent throughout. It is neither hæmorrhagic nor cystic, yet its histological characters are quite unmistakably those of a myeloid sarcoma or so-called myeloma. Anything more unlike ' hæmorrhagic granulation tissue ' it would be difficult to imagine, and the case is a striking commentary on the hypothesis advanced by certain American authors that myeloid sarcoma is neither more nor less than a ' chronic hæmorrhagic osteomyelitis '.

A second point of interest is the presence of enlarged axillary glands on the same side as the tumour. It is unfortunate that the condition of the patient did not permit of their removal at the time of operation, as a histological investigation would have been most desirable. Enlargement of associated lymph glands is by no means rare in cases of myeloid sarcoma ; but, so far, no conclusive evidence has been produced that this is due to metastatic deposits. Jonathan Hutchinson,[2] in his *Illustrations of Clinical Surgery*, figures a popliteal lymph gland from a case of myeloid tumour of the tibia, in which " the peculiar tints of the gland growth were very striking, and closely resembled those of the parent tumour ". No record of microscopic examination had been preserved, however. Hutchinson adds, " I do not recollect to have ever seen the glandular growths in well-marked myeloid disease prove troublesome. It is very exceptional for the glands to enlarge at all, and when they do so it is only to a moderate extent, and with apparently a good possibility of spontaneous retrocession ".

I would suggest that lymph-gland enlargement in myeloid sarcoma may be due to the absorption of blood and disintegration products of the tumour by the lymphatics, and in certain cases it is conceivable that this might produce the appearances figured by Mr. Hutchinson.

In view of the known behaviour of sarcoma generally, one might reasonably anticipate that dissemination of myeloid sarcoma, if and when it does occur, would be by way of the blood-stream and not by the lymphatics. That a tumour of this kind is capable of penetrating and spreading along the veins was conclusively shown in a case reported by Dr. Bristowe[3] as long ago as 1855, where a number of large veins were filled with tumour tissue having naked-eye and microscopic characters identical with those of the primary growth. In spite of the fact that tumour-filled veins were present in the amputation flaps, the operation wound ultimately healed satisfactorily, although the flaps sloughed in the first instance. It may be that this accident was responsible for the satisfactory healing which followed. The after-history is not given.

SUMMARY.

A case of myeloid sarcoma of the lower end of the radius is reported in which the tumour, measuring 2½ in. by 1½ in., was white throughout. The patient was a small girl of six years, and the swelling had first been noticed three years before. As the tumour had burst through its bony capsule over a large area and was extensively invading the soft tissues, treatment by amputation was decided on, and carried out. Histologically, the growth was a typical myeloid sarcoma (myeloma). The axillary glands on the affected side were enlarged, but had completely subsided by the time the patient was discharged from hospital.

I have much pleasure in acknowledging Mr. Braithwaite's kindness in according me every facility for the investigation of this case, and my thanks are due also to Dr. Leo. A. Rowden for the accompanying radiograph.

REFERENCES.

[1] Paget, James, *Lectures on Surgical Pathology*, London, 1853, ii, 214.
[2] Hutchinson, Jonathan, *Illustrations of Clinical Surgery*, London, 1875, *Plate LVII*, and pp. 77–80.
[3] Bristowe, J. S., " Myeloid Tumour of the Humerus ", *Trans. Path. Soc. Lond.*, 1856, vii, 351.

SOME CYSTOSCOPIC APPEARANCES IN TUBERCULOSIS OF THE URINARY TRACT.

By W. GIRLING BALL, London.

This paper is intended to illustrate some of the pathological changes which may be observed in the bladder in cases of genito-urinary tuberculosis.

It is now a generally accepted fact that in about 80 to 90 per cent of cases of vesical tuberculosis the primary focus of infection is situated in the kidney, this figure being placed even higher by some observers; the genitalia in the male provide the remainder. Primary tuberculosis of the bladder is very rare, its existence being denied by many observers. It only too frequently happens that there are no renal symptoms in even advanced cases of tuberculous disease of the kidney, whereas the vesical symptoms may be very prominent and lead the clinician to think that the disease is limited to the bladder. Cystoscopy—especially when combined with the use of ureteric catheterization—however, has taught us the true nature of these cases, and has made more obvious the rarity of a primary lesion of the bladder, owing to the greater ability to demonstrate the existence of renal lesions which could not be demonstrated prior to the introduction of this method of investigation. Cases of primary infection have been recorded, however, and one has come under my observation which was proved up to the hilt.*

Renal tuberculosis is a slowly progressive disease which unfortunately may not give rise to symptoms of a sufficiently definite character to cause the affected person to seek advice until, it may be, considerable destruction of the affected organ has taken place; in fact, the involvement of the bladder, with coincident symptoms, may be the first indication of this serious malady. Symptoms indicating involvement of the kidney are of slow development and may be absent altogether, even when that organ has been completely destroyed, dysuria associated with frequent micturition at night as well as by day being commonly the first evidence of disease.

With primary infection of the genitalia, on the other hand, the involvement of the testicle soon attracts attention owing to the external situation of that organ, and it is rare for bladder symptoms to develop at an early stage of the symptomatic history of the disease.

Ability to recognize the appearances seen in the bladder by cystoscopic examination is therefore of great importance in the diagnosis of renal tuberculosis, more especially in demonstrating which kidney is at fault, as in 80 to 90 per cent of cases, so it is stated, one kidney only is affected in the early stages.

It is frequently, from the technical point of view, a difficult matter to carry out a satisfactory cystoscopic examination in this condition. Prior to the appearance of tuberculous lesions in the bladder mucosa little difficulty presents itself; but when the latter exist, then, owing either to a spasm in the early stages or to infiltration of the muscle of the bladder wall in the later stages, it is often impossible to make a thorough investigation unless the patient is under a general anæsthetic, the distention of the bladder with fluid in sufficient amount causing severe pain. It is my practice, whenever a tuberculous infection is suspected, to adopt this procedure; even then, extreme care must be taken

* Shown by Mr. Jocelyn Swan at the Cancer Hospital at a recent meeting of the Urological Section of the Royal Society of Medicine.

to avoid over-distention of the bladder, otherwise hæmorrhage may be caused and irreparable damage supervene, such as the lighting up of a latent lesion or the introduction of a secondary infection, results easily induced by even slight trauma.

There is, moreover, a further difficulty in diagnosis from the pathological aspect: namely, that lesions may have assumed such characters, especially in the presence of secondary infection with other bacteria, as to render them indistinguishable from those associated with other forms of cystitis; even in the absence of the latter, the bladder may have become so extensively involved in the tuberculous process as to make it impossible to identify the original site of the bladder lesion, which may be the only clue indicating its possible origin from the kidney. It is true that rest in bed, free diuresis, and the use of urinary antiseptics will frequently so improve such conditions, even in advanced cases, as to make a diagnosis possible; but such attempts, even when successful, always cause delay. For this reason it is an extremely important matter that an early investigation of the bladder should be carried out in all suspected cases of infection, firstly in order to define the existence of any abnormality in the effluxes from the ureteric orifice or in the bladder mucosa, and secondly to recognize the position of such changes in order to obtain an indication of the site of the primary lesion. The latter point requires emphasizing, for the finding of tubercle bacilli in urine containing blood or pus, with symptoms of cystitis, only indicates the presence of urinary tuberculosis; it offers no suggestion as to the requisite treatment. This the cystoscope alone can give in the absence of localizing symptoms, which, as above stated, may be completely absent; even if the latter are present, confirmation is always necessary.

Some writers state that it is unwise to carry out cystoscopic examinations in cases of tuberculous cystitis owing to the liability of causing further damage. It is agreed that it is unwise to employ this method of investigation during the acute symptoms of bladder infection, or more often than is necessary in the chronic stage; but it is obviously important that an exact location of the bladder lesions should be made as soon as possible, in order that the correct treatment may be determined upon. This information cannot be obtained without a cystoscopic examination, which should therefore be insisted on.

The illustrations here shown are taken from cases of unilateral renal tuberculosis (with the exception of *Figs.* 272 and 273), and indicate the character of the lesions met with in the bladder in the early stages of its involvement.

The earliest cystoscopic appearance observed is the discharge of blood, pus, or caseous material from the ureteric orifice, or from both orifices if both kidneys are affected. These effluxes, in the absence of lesions in the vesical mucosa, are demonstrable only when it is the custom of the observer to carry out routine cystoscopic examinations in all cases of hæmaturia and pyuria, for their existence is often unassociated with other symptoms or signs. Owing to the fact that the discharges are frequently intermittent, especially in the case of hæmaturia, which is a relatively uncommon symptom of the disease, and are dependent on the pathological changes taking place in the kidneys, several observations may be required in order to demonstrate their source; the period of their discharge is obviously the only suitable time at which the case should be investigated by this method. Even then the discharge may be so small in amount that it may not be distinguishable to the naked eye; under these circumstances the origin of the blood or pus can only be proved by bilateral ureteric catheterization and subsequent examination of the urine collected. At this stage the bladder mucosa frequently shows no change at all, which, from the therapeutic point of view, is the ideal period at which to make a diagnosis. As, however, hæmaturia and pyuria are the signs of diseases other than tubercle, it may not be possible, in the absence of bladder lesions and a failure to demonstrate the presence of tubercle bacilli, to make a diagnosis of tuberculosis; nevertheless, the persistence of the hæmaturia or pyuria thus observed by cystoscopy as coming from one kidney is indicative of its origin, and may, by a process of exclusion, fully justify an exploration of the affected organ.

Fig. 263 illustrates the typical appearance of a discharge of blood from the ureteric orifice. *Fig.* 264 illustrates the discharge of inspissated pus.

The case shown in *Fig.* 264 was of interest, for, on examination, the portion of the bladder wall on which the ureteric orifice was mounted was bulging into the bladder for a considerable distance, the orifice itself, situated at its apex, being plugged with inspissated pus or caseous material. The discharge of the pus was only obtained by passing a ureteric catheter into the orifice, when it ran freely. The patient had a very large pyonephrosis which drained into the bladder after this manœuvre. It is noticeable that there was very little change in the surrounding bladder wall, which was of the same appearance elsewhere and showed no abnormal lesions. At the subsequent operation it was found that the kidney of that side was completely destroyed. The patient alleged that he had not had any symptoms until fourteen days previously.

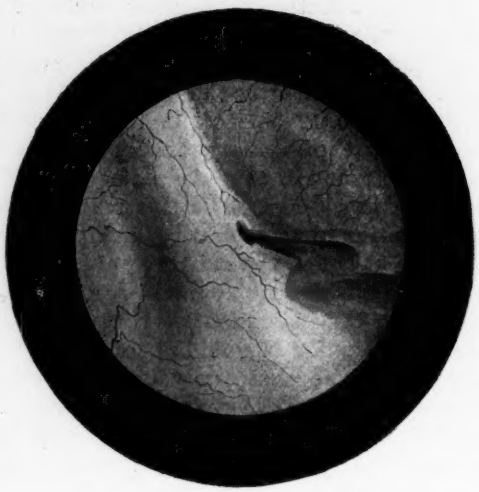


FIG. 263.

The picture in this case may be described as an extreme appearance of prevesical involvement, and is very infrequently seen; the more common condition is to find that the discharge of pus is small in amount and difficult to observe cystoscopically, and its presence may be demonstrable only by ureteric catheterization. The two pictures, however, serve to illustrate the desirability of early cystoscopic examination in order to establish the origin of pyuria or hæmaturia.

Let us turn now to the changes which take place in the bladder wall itself. These vary largely with the stage of infection; broadly speaking, the degree of involvement of

FIG. 264.

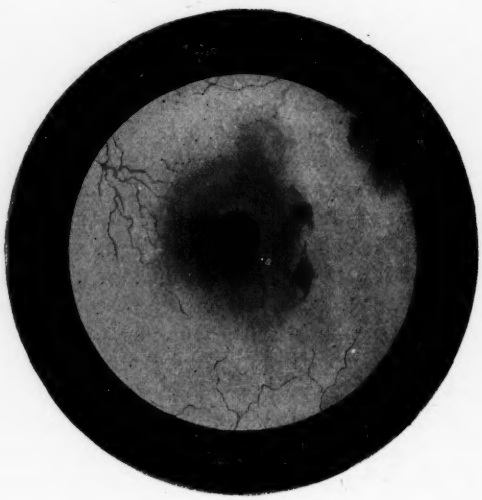


FIG. 265.

the bladder wall is an indication of the extent of the disease in the kidney. It is said that patients often exhibit symptoms of vesical irritation prior to the appearance of bladder lesions, such being attributed to reflex action. In my experience this is not the case; there is usually some change occurring when these symptoms commence, although it does not necessarily exhibit the characteristics of a tuberculous lesion. It is conceivable, how-

ever, that lesions of the lower end of the ureter may give rise to vesical symptoms without actual involvement of the bladder mucosa.

The earliest changes are usually found in near relationship to the primary focus of infection—i.e., around the ureteric orifice in cases of renal origin, and over the vesicle or prostate when the genital organs are the offenders. Sometimes, however, the first bladder lesions make their appearance in other areas of that structure, leaving the sites above mentioned free.

FIG. 266.

In cases of renal tuberculosis the lips of the vesical orifice of the ureter become swollen, hyperæmic, œdematous, and may have bullæ around them. These bullæ, which are semitranslucent in appearance, may become heaped up on each other (bullous œdema), so as to hide the site of the orifice, and the œdema may spread on to the base of the bladder and trigone. This condition is considered by some to be pathognomonic of tuberculous infection ; but there is no doubt that it may be found in other chronic infective conditions. In fact, the appearances just mentioned only indicate the existence of an infection of the renal tissues. It is difficult to obtain a suitable illustration of the congested state of the ureteric orifice (shown in *Fig.* 265), but *Fig.* 266 illustrates most beautifully the condition of bullous œdema.

When this patient was first seen, he gave a history of two years' pyuria, with the symptoms of cystitis, and a loss of 2 stone in weight. He was thought to be suffering from tuberculous disease of the urinary tract, although after repeated investigation the bacilli had not been demonstrated.

FIG. 267.

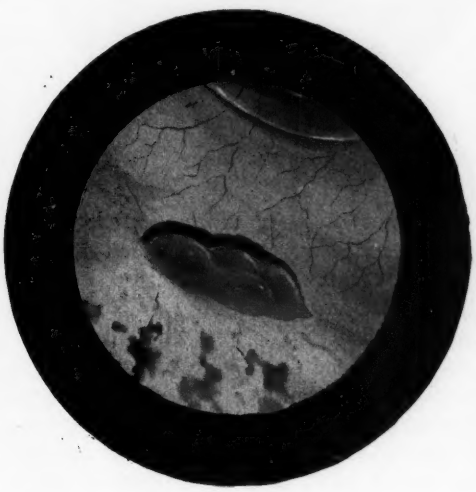


FIG. 268.

The bacteriological examination always showed the presence of *B. coli communis* and streptococci. Both of the seminal vesicles were hard and nodular, as also was the prostate. The cystoscopic examination did not give any satisfactory clue as to the origin of the condition, showing the bladder to be in a condition of severe, diffuse, chronic cystitis, with the suggestion of most advanced changes in the region of the left ureteric orifice. There was no obvious ulceration,

the mucosa being tremendously œdematous and covered with shreds of thick muco-pus which could not be washed away. There were no renal symptoms.

The patient was treated by rest in bed, free diuresis, and antiseptics, and as he preferred to have this carried out in his own home, he did not come under observation again for six months. He was then very much better in his general condition, and his vesical symptoms had much improved; renal symptoms were still absent. The appearances in his bladder had completely altered, and illustrate the advantage of improving the condition of cystitis prior to coming to a definite conclusion as to the nature of the lesion. The condition shown in the figure was the only abnormality found in the bladder. The left ureteric orifice, discharging pus, could just be seen, surrounded by bullous œdema. The right ureteric orifice was natural in appearance. On bacteriological examination of the urine the *B. coli communis* only was found, and tubercle bacilli were still absent.

Nephrectomy was performed, and the cortex of the kidney was found to be the site of multiple large chronic abscesses, which on microscopic section failed to demonstrate the characters of a tuberculous infection, though the lesions appeared to be of that type.

Although this case was one of chronic *B. coli* and streptococcal infection of the kidney, the appearances seen around the ureteric orifice serve well to illustrate the changes which may be seen in cases of chronic tuberculous nephritis.

The swelling and congestion tend to spread over the mucosa of the bladder base around the orifice of the ureter. The appearance of a delicate network of dilated blood-vessels arranged in a flame-like fashion in this region, or even more extensive submucous hæmorrhage, is characteristic (*Figs.* 265, 267, 268). All the patients presenting the above appearances had advanced tuberculosis in the corresponding kidney, as was proved by subsequent nephrectomy. In the first case (*Fig.* 265) the renal tissue had been completely destroyed and a large pyonephrosis had formed. The ureteric orifice in two cases (*Fig.* 265 and *Fig.* 267) illustrates the typical 'golf-hole' appearance so commonly associated with an inactive kidney or a blocked ureter. In the second case (*Fig.* 267) it is seen that the hæmorrhagic patches are lying above the ureteric orifice, behind the interureteric bar, more or less along the line of the lower end of the ureter; this is a common site for the appearance of early tuberculous lesions, and very suggestive of a direct infection of the bladder mucosa thsough its wall from lesions in the ureter.

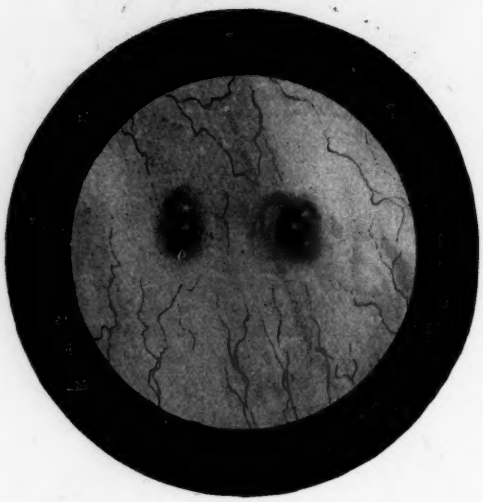


FIG. 269.

The changes so far described are identical with those associated with other forms of chronic inflammation, and must not be regarded as pathognomonic of a tuberculous infection.

Miliary tubercles, the characteristic lesions of tuberculosis, are not seen so commonly as might be expected; when they are present, however, they possess appearances analogous to similar lesions seen in other mucous membranes, first as grey, pearl-like nodules with a smooth surface, and later as minute yellow areas of caseation, the size of a pin's head (*Fig.* 269), usually multiple, slightlv raised from the surface, with clear-cut margins, and with a tendency to increase in size and to coalesce; there is a small zone of hyperæmia around each tubercle, which, if the latter are large in number, tends to cause congestion of a considerable area of the bladder mucosa. The tubercles are usually situated around the ureteric orifice, but may be found at some point a little distance from it. In the early stages of vesical infection the rest of the bladder mucosa maintains its normal appearance. The same lesions may be seen situated over the vesicle or prostate when these organs are the primary foci of infection.

Eventually these tubercles break down and leave small shallow ulcers with a sharply defined, slightly raised, undermined edge, often bright red in colour (*Fig.* 270), usually a little ragged owing to the adhesions of mucus, with a shallow necrotic base covered with a yellow slough, which later clears away and leaves unhealthy pinkish-blue granulations. When several tubercles fuse together, these ulcers may be of quite a considerable size, exhibiting rather irregular edges due to their fusion, but otherwise having similar characters. As the disease advances, these lesions become more numerous and spread to a distance in the bladder wall far from the orifice of the originally infected ureter. The mucosa surrounding these ulcers varies considerably; sometimes it is natural in appearance; at others there is a deep zone of congestion, especially when many ulcers are present, indicating a more active stage of the disease. Yet again an appearance of healing may be observed at the edge of an ulcer while it spreads in another direction; they may even heal completely, leaving weak cicatrices which are very prone to break down again; this is characteristic of a tuberculous lesion. At other times the ulcer may be deeply excavated, especially when the primary origin has been in the seminal vesicle or the prostate; the edges of such an ulcer are usually irregular and undermined, although

FIG. 270.

FIG. 271.

not markedly raised from the surface of the bladder mucosa; the base is frequently occupied by blood-clot in the recent state or a slough in the later stages.

In rare instances masses may be seen, sometimes having a papillomatous surface, which may be spoken of as 'tuberculous granulomata.'

The appearances seen in *Fig.* 270 are typical: the ureteric orifice with a swollen margin is seen at the lower edge of the picture; extending in a backward direction from this along the line of the ureter can be seen a number of small shallow ulcers of characteristic appearance. *Fig.* 271 represents the left ureteric orifice of the same case; the two pictures demonstrate the marked differences in appearance which may be seen in the same bladder, the mucosa around the lesions being deeply congested, whereas that on the normal side is quite natural.

This patient was a young girl who had never had any renal symptoms at all, and who for four months before she had come under observation was suffering from increased frequency of micturition. No tubercle bacilli were found in the urine after repeated examination. Nephrectomy was performed, and two caseous tuberculous foci discharging into the pelvis were found in the kidney, the renal pelvis being studded with tubercles. The bladder exhibited the changes shown. She made a complete recovery, the badder at the present time exhibiting normal cystoscopic appearances, with the exception of a white scar at the site of the ulceration (*Fig.* 274).

Fig. 272 represents the appearances of a single ulcer found in the bladder of a man complaining of vesical symptoms who had had his right testicle removed for tuberculous disease some months previously, and who at the time this picture was taken had a hard, nodular seminal vesicle underlying the site of the ulcer. The clear-cut margins with the

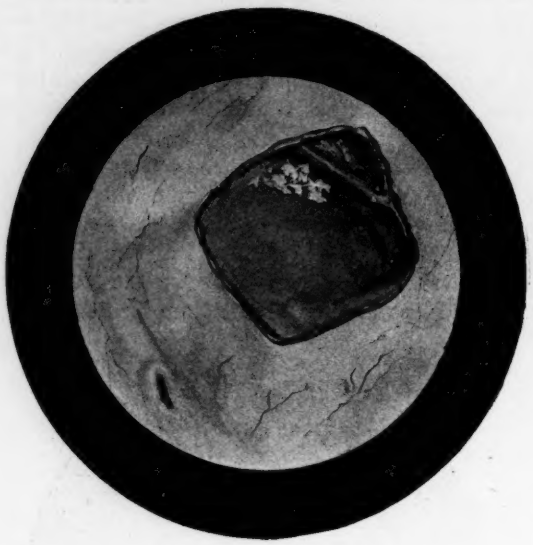


FIG. 272.

FIG. 273.

pale reddish base, with practically no undermining of the edges, give a characteristic impression, more especially seen in the near view (*Fig.* 273), which demonstrates the pinkish-blue appearance of the granulations. Attempts were made to prove that the kidneys were infected, but failed, as might be expected from the normal appearance of the ureteric orifices.

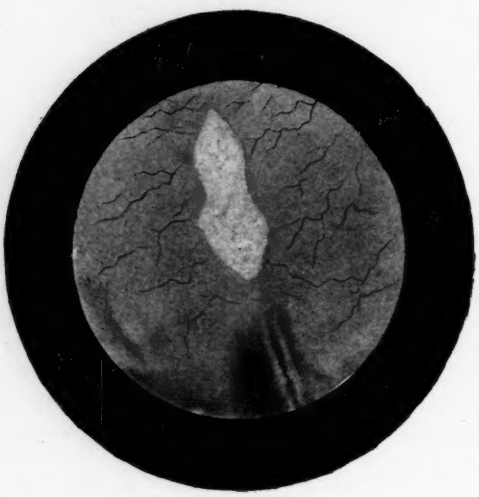


FIG. 274.

Tuberculous cystitis has a tendency to remain localized until other infective bacteria take part in the process. With the onset of a secondary infection, the changes already described become less obvious. The mucosa of the bladder wall between the lesions which up to this period retains a more or less normal appearance, now exhibits changes usually associated with a chronic cystitis of pyogenic origin, which masks the characteristic appearances of a tuberculous lesion. It is this change which so frequently makes it difficult to arrive at a correct diagnosis.

In the stage of healing, scars form in the bladder at the site of ulcers (*Fig.* 274); these, though having the characters of scars elsewhere, have a ready tendency to break down and re-ulcerate.

The 'golf-hole' ureteric orifice through which there is no discharge, with the orifice drawn up to a higher level than that of the opposite side, is the common appearance seen in the case of a long-standing active or calcified tuberculous kidney. It is no doubt due to infiltration of the ureteric

wall with inflammatory material, which renders its lips rigid and non-contracting and apparently protruding further into the bladder cavity than normal; the shortened and thickened ureter can often be seen producing a ridge (*Fig.* 275) in the bladder wall on the renal side of the ureteric orifice. The picture shown came from a case of advanced tuberculous disease of the kidney which had become secondarily infected with *B. coli communis*. It is interesting to note the absence of cystitis in this case despite the presence of symptoms of renal disease extending over a period of seven months.

In the long-standing cases the bladder wall usually becomes contracted and thickened owing to widespread infiltration; masses of caseous material may even be deposited in its structure.

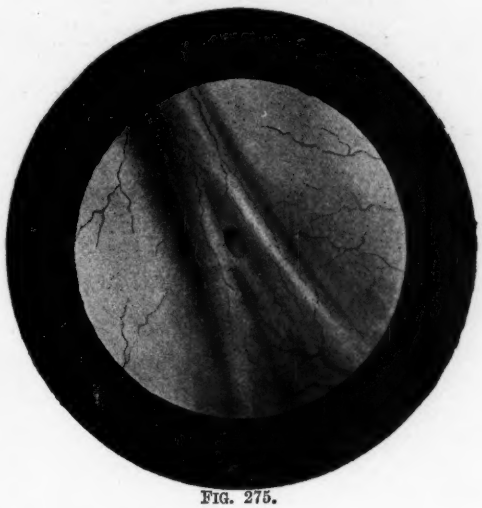


FIG. 275.

Such are some of the appearances which may be observed; but, as has been stated, it is often by no means easy to be sure that lesions seen in the bladder are of tuberculous origin. The history of the condition, with typical symptoms, especially if tubercle bacilli can be demonstrated in the urinary deposit either by film or cultural preparation, and more certainly by guinea-pig inoculation, will, as a rule, make the diagnosis of urinary tuberculosis certain; if the bacilli are not found on the first investigation, repeated examinations may lead to a successful result; if sufficient care is taken they can be found in the majority of cases. But if these classical symptoms and signs fail to indicate the nature of the condition, cystoscopic examination may be the only means of arriving at a diagnosis; in every case it is the only means of indicating which kidney is the primary source of the vesical lesions, and the only method, combined with ureteric catheterization, of defining a unilateral infection These investigations demand the greatest care and patience, but they are worth it when good results are obtainable. It is clear that the diagnosis should be made at the earliest possible moment after the onset in order to obtain the best results, and this may only be achieved by the use of the cystoscope.

I am greatly indebted to Mr. W. Thornton Shiells for the care and skill with which he has represented the cystoscopic appearances.

AN ACORMOUS EMBRYOMA, CONSISTING OF A HYDROCEPHALIC FŒTAL HEAD CONTAINED WITHIN AN OVARIAN CYST, IN A CHILD 2½ YEARS OF AGE: OVARIOTOMY.

By C. E. SHATTOCK, London.

The diseased ovary in this case was removed by the author from a child 2½ years of age who had suffered from indefinite abdominal symptoms for six weeks. On examination, a firm, clearly defined, freely movable tumour was palpable in the mid-line between the pubes and umbilicus. The parents and three other children were healthy.

The specimen, which may be described somewhat fully for the sake of any future reference that may be made to it, is represented of the natural size in the accompanying figure (*Fig.* 276).

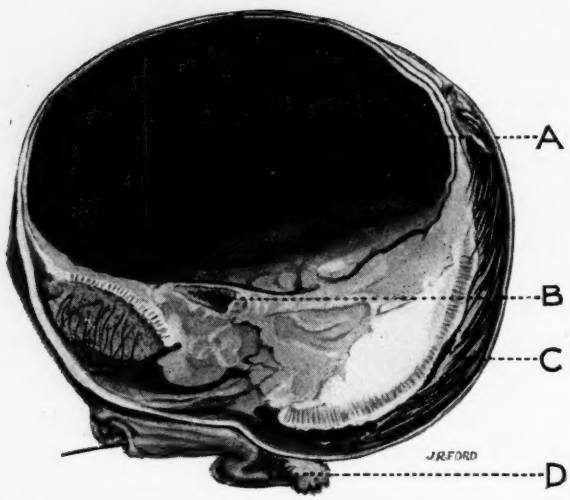


Fig. 276.—A sagittal section of the acormous or trunkless ovarian embryoma described in the text. Most externally is seen the thin-walled ovarian cyst. This encloses the embryo, which is represented solely by a hydrocephalic head. The mass of dark hair on the right-hand side growing from the skin is apparently that of the scalp. At the bottom of the figure, and connected with the exterior of the ovarian cyst, there is a normal Fallopian tube. **A**, Interior of the hydrocephalic brain; **B**, Bone, representing a basis cranii; **C**, Thick, dark hair growing from a scalp; **D**, Fallopian tube normally attached to the exterior of the distended ovary. *The specimen is now in the Museum of the Royal College of Surgeons, London [General Pathology: Cysts].* (*Natural size.*)

The specimen consists of half of the left ovary of a child, enlarged by the growth of an embryoma, which is composed solely of the head of a hydrocephalic fœtus and completely fills a cyst in the ovary. The soft, easily separable, hydrocephalic brain measures 5·5 × 3 cm. in chief diameters, and is lined with ependyma through which the subjacent vessels are visible. Below the middle of the distended brain there is an elongated piece of cancellous bone closed in with a layer of compact bone, which may be taken as the basis cranii. Below the bone, and extending behind it as far as the skin, and beneath the brain, there is a triangular mass of young connective tissue and fat, in which microscopic examination demonstrates also the presence of a few islets of cartilage, and a compact, ill-defined mass of well-developed, intersecting bundles of unstriped muscle fibres: there is no clue as to what these structures morphologically represent. Lastly, there are included groups of ganglia furnished with large, typical nerve-cells. The skin over the triangular mass of connective tissue already referred to is thickly covered with somewhat stiff dark hair embedded in sebum; the hair lies immediately against the inner surface of the enveloping

cyst, which is so thin that the former is obvious through it. The connection between the embryoma and the wall of this half of the cyst is limited to a strand of connective tissue which passes from the lower aspect of the triangular mass to the opposite side of the cyst. In front of this connection, the solid tissue of the embryoma is confined to a small oval sessile process projecting into the cavity of the cyst below (*see Fig.* 276), and, more anteriorly, to a stretch of skin bearing hairs embedded in sebum. The proper wall of the cyst, the skin, and cerebral substance are traceable from the base, becoming more and more attenuated, to the vertex. The epithelial investment of the oval mass projecting into the cyst below the base of the skull affords matter for consideration. For whilst it is covered mostly with ordinary epidermis, and furnished with hairs and sebaceous glands, the epithelium for a short distance is columnar-celled and ciliated, the one being continued into the other. Whether this represents a mucocutaneous junction, it is impossible to say; there is no pertaining unstriped muscle. The cavity of the hydrocephalic brain is subdivided into an anterior and posterior fossa by means of a subjacent ridge continuous with the central process of bone before mentioned, the general disposition corresponding with that of the interior of the base of the skull.

This specimen appears to be unique. The embryoma is represented by a head without either trunk or limbs.

Such an acormous or trunkless condition is recognized in the case of acardiac intrauterine monsters; and although there is no example of it in the extensive Teratological Collection at the Royal College of Surgeons, London, full references to twelve instances are given in Ahlfeld's exhaustive *Missbildungen des Menschen*, 1880; and it is the condition present in what is one of the most remarkable forms of double monster yet observed, viz., that of Hunter (No. 166, *Teratological Series, Roy. Coll. Surgeons*), which was described by Sir Everard Home in the *Philosophical Transactions*, Vol. lxxx, p. 296. This preparation is the skull of an Indian child, to the anterior fontanelle of which there is attached a second inverted skull, almost equally large, the faces of the two being turned in opposite directions. During life the second head was surmounted by a short neck, which was soft at the age of two years, and quite firm and cartilaginous at four. The brains were found, after death, to be distinct; but their dura mater was coherent. The facial movements of the upper head were reflex, and not controlled by the feelings of the child; the eyelids were usually open, even when the child was asleep.

Hunter's specimen is explicable as a double monster of which the second head represents a fœtus, all the parts of the latter, except the head, having aborted so as to result in an acormous parasite.

The most common form of double monster is that in which the union is back to back, in the sacral region—pygopagus. Of head to head fusion—craniopagus—there is one example only in the College Museum (No. 165); the twins are immature, and in other ways abnormal (*Lancet*, 1876, Aug. 26). According to the site of union, the condition is subdivided into craniopagus frontalis, craniopagus occipitalis, and craniopagus parietalis. Hunter's specimen belongs to the 'parasitic' sub-variety, the second individual being a mere appendage to the host. Three other specimens of parasitic craniopagus were discovered by Ahlfeld in teratological literature.

The specimen here recorded may be regarded as the complement of another, also in the College of Surgeons, which was fully described by Professor S. G. Shattock (*Path. Soc. Trans.*, Vol. lviii, p. 267) in a paper devoted to the so-called dermoid cysts of the ovary, in which cysts the embryoma may have aborted and dwindled to a patch of piliferous skin overlying an eminence of subcutaneous fat. This specimen (No. 1228·1) comprises a trunk, a cœlomic cavity containing a blind loop of intestine, and processes representing limbs, but no head: the embryoma is acephalous, and not—as in the specimen under consideration—acormous. What is physiologically remarkable, moreover, is that in the mass of fat of which the trunk is largely composed, there is a well-formed pelvis, and that from the skin over the pubes there has grown a well-pronounced tuft of hair. This obviously marks the pubescence of the intra-ovarian parasite, which must be explained by the access of endocrine from the maternal blood to the embryoma, when the bearer herself attained puberty, seeing that there are no sexual glands in the parasite, and that the bearer was an adult (loc. cit.).

The theory propounded in the paper referred to is at least one possible way of viewing

the origin of intra-ovarian teratomata, and may be very briefly referred to. It is that one or more of the primordial germ cells in the developing embryo are, at a very early stage, 'fertilized' by spermatozoa left over after the normal physiological fertilization which gives rise to the main embryo: this later secondary and spurious fertilization gives rise to the intra-ovarian monster which develops to a varying extent within the genital gland of the growing embryo. In such a process there would be no histological maturation of the fœtal ovum by the extrusion of polar globules: the 'fertilizing' spermatozoa would act mechanically only, and stimulate the ovarian cell to start subdividing, as may be effected mechanically in lower forms of life, and in the ova of the frog by puncture of the unfertilized ova.

Lastly, there is a further point of interest in the coloration of the hair. The hair of the scalp of the child is pale fawn; that of the scalp of the father and the mother is brownish black, and equally so; that of the scalp of the embryoma is brownish black, but not so deep at that of the parents. Now double monsters (misdeveloped uniovular or homologous twins) are not only of the same sex, but the hair of the scalp is of the same colour. The coloration of the hair of the ovarian teratomata (so-called dermoid cysts) may not, in fact, correspond with that of the host. This favours the hypothesis that the embryoma is due to the introduction of a 'fertilizing' agent which gains access to the embryonic ovary, rather than that the embryoma is an abnormal product of the developing embryo itself.

The name 'epiembryogenesis' given to the theory, so to say, was devised to indicate that one embryo (the intra-ovarian) is produced 'on the top' of another.

STUDIES IN GALL-BLADDER PATHOLOGY.

By Professor WILLIAM BOYD, University of Manitoba.

SUMMARY OF CONTENTS.

I.—Introductory.
II.—Methods of Investigation :—
1. The dissecting microscope.
2. Staining reactions.
3. The polarizing microscope.
4. Closed diaphragm.
5. Microchemical reactions.
III.—Amount of Cholesterol in Strawberry Gall-bladder.
IV.—Distribution of the Lipoid.
V.—What is the Cause of the Lipoid Deposit ?
VI.—Relation of Lipoid to Gall-stone Formation.
VII.—Clinical Significance of Lipoid Deposits.
VIII.—Comparative Anatomy of the Gall-bladder.
IX.—Function of the Gall-bladder.

I. INTRODUCTORY.

The pathological problems presented by that profitable stone-quarry, the gall-bladder, are numerous and varied. What is the route of infection ? Is it hæmatogenous, lymphogenous, or by the bile-duct ? How are stones formed ? What is the explanation of the symptoms of gall-bladder dyspepsia ? What is the relation of cholesterol to gall-bladder disease ? What is the connection between hepatitis and cholecystitis ? What is the meaning of the strawberry gall-bladder ? And, finally, what is the function of the gall-bladder ? In the present communication it is only possible to touch upon one or two of these.

In the past, far too much stress has been laid upon the presence of calculi. Monographs have been written on gall-stones and the pathological alterations of the bile. But calculi are incidental, not essential, to gall-bladder disease. Their presence may lead to dramatic symptoms which compel attention both on the part of the patient and his physician ; but they have distracted attention from the essential problem, namely, that of the gall-bladder itself.

When the surgeon opens the abdomen in search of a diseased gall-bladder he may find one of three conditions :—

1. Acute inflammation, usually accompanied by the presence of calculi.
2. Chronic inflammation, with or without calculi.
3. The gall-bladder may appear little if at all altered (though usually its normal bluish semi-translucent appearance is lost) ; but when it is opened the mucosa is seen to be dotted with minute yellow spots, a condition to which the name of strawberry gall-bladder was first given by McCarty.[1] A study of this peculiar condition may throw some light on the general question of gall-bladder pathology.

The Strawberry Gall-bladder.—The term strawberry gall-bladder was used by McCarty because of the resemblance which the tiny yellow specks, scattered over a reddish background, bore to a ripe strawberry. At first McCarty considered that the appearance was to be explained by a desquamation of the epithelium covering the villi, thereby allowing the underlying connective tissue to become stained with bile. Later he recognized that

the yellow material must be lipoid in nature, for it stained red with Scharlach R ; moreover the loss of epithelium was merely due to trauma.

My own studies upon the nature of this lipoid were at first purely histological, but as the scope of the investigation widened, it was found necessary to employ chemical and experimental methods, and finally excursions had to be made into the realm of comparative anatomy.

II. METHODS OF INVESTIGATION.

The first point to be determined was the nature of the lipoid. The material, which was obtained absolutely fresh from the operating room, was stained with the usual fat stains, Scharlach R or Sudan III. and with osmic acid. Lorrain Smith's Nile blue sulphate method was used for the detection of fatty acids. In some cases the Weigert-Pal method for myelin was employed. Sometimes the tissues were examined fresh, but the best results were obtained with frozen sections cut after preliminary fixation in formalin. Paraffin sections were studied in every case for the finer histological changes. Three of

FIG. 277.—Mucous membrane of a strawberry gall-bladder at an early stage. The patches of lipoid are whitish in colour.

the simplest and at the same time the most valuable methods remain to be mentioned. These were the low-power binocular or dissecting microscope, whereby a direct stereoscopic view of the mucosa could be obtained, the polarizing microscope, and the ordinary microscope with the diaphragm closed for the study of the unstained section.

1. The Dissecting Microscope.—For the study of many diseased tissues this is an instrument of the greatest value. It gives one an intermediate picture between that of the naked eye and of the microscopic slide. The idea one gets of the structure of the gall-bladder, both in health and disease, is entirely different from that derived from the study of sections.

Moreover, the histological study of the normal gall-bladder is beset with difficulties. I have found autopsy material absolutely useless. Even when the gall-bladder is removed as early as three hours after death, degenerative changes of a most serious nature have occurred in the villi, and the epithelium is usually completely desquamated or else indistinguishable. In studying this phenomenon, portions of fresh gall-bladders removed at

operation were kept for varying periods in water, in a moist atmosphere, and in bile. Under these circumstances the changes were not anything like so marked as in the autopsy specimens, but in the case of the tissue kept in bile they were very considerable. The degenerative changes are therefore probably due to the action of the bile on the delicate epithelium.

In text-books of anatomy one reads the statement that the mucous membrane of the normal gall-bladder is thrown into folds. But this conveys little to the mind until the gall-bladder wall is viewed direct under the dissecting binocular microscope. When the fresh gall-bladder, immersed in water, is observed by reflected daylight or, still better, by the brilliant light of an electric arc, the picture is a remarkable and beautiful one. As if one were gazing into the depths of a marine pool at sea-weeds and sea-anemones, tall graceful folds and membranes, gossamer-like in their delicacy, can be seen floating in the ambient fluid. The entire inner surface is divided by these membranes into a series of polygonal spaces, and each of these spaces resembles a little courtyard surrounded by high

FIG. 278.—Masses of lipoid in the stroma. The surface epithelium is intact. Stained with Scharlach R.

though delicate walls. In microscopic sections the membranes, cut transversely, appear as villi. They are not true villi, but the term is allowable because of its convenience. It is a striking picture and, as we shall see later, one which at once suggests that the idea of the gall-bladder being a mere reservoir is absolutely untenable. Such a highly specialized structure can be for one purpose only, and that purpose is absorption.

In the strawberry gall-bladder the picture is even more wonderful. The lipoid in marked cases is seen in the form of dense yellow masses of dull hue. The graceful, fragile, gossamer folds of mucosa are completely altered in appearance, being loaded down by the dense, opaque lipoid much as a delicate birch tree might be weighed down by a load of snow. Sometimes the lipoid is confined to the summit of the ridges; sometimes, when the ridge is viewed in profile, it can be traced down into the depth of the recesses. In the severe cases the distribution is widespread. In the milder cases it is more patchy, picking out a fold here and there, and giving the mucosa the appearance of a mountain ridge retaining only an occasional patch of the winter's snow (*Fig.* 277). Before it is fixed in formalin the lipoid can be lifted up by means of a needle in long strings as if it consisted of

molasses. The material thus removed can be further studied by methods presently to be described.

2. **Staining Reactions.**—The yellow material of the strawberry gall-bladder gives the usual reaction for fat. It is soluble in alcohol, ether, and chloroform, so that it cannot be seen in paraffin sections. It stains red with Scharlach R and Sudan III, and black with osmic acid. In these respects it behaves like ordinary neutral fat, which is an ester of glycerin, and which is sometimes found in large amount in the subserous tissue and in the deeper layers of the fibrous coat of the diseased gall-bladder. Although evidently of lipoid nature, it differs from ordinary fat in some most important particulars. With Scharlach R it does not take on quite the same brilliant scarlet which neutral fat displays. Moreover, it is quite often granular in form, although not infrequently globular (*Fig.* 278); but in the latter case the globules are always small, and often irregular in form. The neutral fat in the deep layers of the wall is in the form of large, spherical globules. Nor is the

FIG. 279.—Deposits of lipoid stained with osmic acid.

staining with osmic acid the same as that of ordinary fat. The black is not a jet black, often more of a grey (*Fig.* 279), and not at all intense.

In order to determine the exact nature of the lipoid other methods had to be employed. Lipoid material may occur in the body as neutral fat (an ester of the alcohol glycerin with a fatty acid), as free fatty acids, as cholesterol, or as cholesterol ester (an ester of the alcohol cholesterol with a fatty acid). All of these stain red with Scharlach R.

Sections of each case were also stained by Lorrain Smith's Nile blue sulphate method. This member of the oxazine series of dyes stains neutral fat rose and fatty acids blue. The lipoid in the mucosa of the strawberry gall-bladder took on sometimes an intermediate violet tint, sometimes a deep blue, whilst the neutral fat in the subserous tissue stained a definite rose.

The question arose as to what colour cholesterol and its compounds would develop with Nile blue. The literature contained no answer to this question, but the reaction of different dyes with various forms of lipoid was determined in the following manner:—

A number of capillary tubes were drawn out, and into each was run first the substance to be tested and then the dye, after which the ends of the tubes were sealed. In this manner

triolein, tripalmitin, tristearin (all glycerin or neutral fats), oleic acid, an alcoholic solution of cholesterol, and cholesterol ester made by the addition of cholesterol crystals to a soap solution, were tested against Scharlach R and Nile blue sulphate. With the Nile blue triolein gave a distinct narrow zone of rose at the junction of the two fluids, oleic acid a bluish violet, and cholesterol and cholesterol ester a deep blue. The reaction with Nile blue showed, therefore, that the lipoid in the mucosa was certainly not neutral fat, but left undecided the question as to whether it consisted of fatty acids or of cholesterol.

3. **The Polarizing Microscope.**—This microscope, so powerful an instrument in the hands of the crystallographer, has not received the recognition it merits in biological work. For researches upon the lipoids it is absolutely essential, and it is remarkable that this extremely simple method has not come into more general use. All that has to be done is to cut a frozen section of the tissue to be examined, and place it, unstained, between Nicol's prisms which may be attached to any microscope. When the prisms are rotated until they are at right angles to one another all material which is non-refractile, or which is isotropic (singly refractile), disappears, and the field of the microscope becomes perfectly dark. Under the same conditions any material which is anisotropic (doubly refractile) shows up brilliantly white upon the black background.

When an unstained frozen section of a gall-bladder containing lipoid is examined with the polarizing microscope the lipoid stands out in the most beautiful and brilliant manner, shining with a silvery radiance which is accentuated by the surrounding darkness. Under higher magnification it was seen sometimes to be in the form of granular amorphous masses, but frequently it appeared as innumerable tiny needle-shaped crystals. In some cases a most curious appearance was observed, bright Maltese crosses standing out against a black background. These crosses were never seen actually in the substance of the tissue; they always appeared to be lying free a little distance from the villi.

Neutral fat and fatty acids are invisible under crossed Nicol's prisms. Cholesterol crystals are brilliantly anisotropic, are of characteristic form, and show an exquisite play of colour, in which reds and blues predominate. Cholesterol esters are also markedly anisotropic, but are pure white.

In order to study the ester some cholesterol crystals were added to oleic acid. They remained quite unchanged. When, however, the reaction was made slightly alkaline (as is the case in the bile), ester formation at once commenced. It was found that a solution of soap could conveniently be substituted for the oleic acid. A drop of the solution was placed on a cover-glass, a few crystals of cholesterol were added, the cover-slip was inverted over a hollow-ground hanging-drop slide, and ringed round with vaseline to prevent evaporation. The process of esterisation could then be watched under the dissecting microscope. In a very short time the crystals began to lose their sharp outline, and the borders became more and more fuzzy. Gradually those peculiar bodies called myelin figures began to form. These were identical in appearance with the figures which develop when the myelin of the medullary sheath of nerves is placed in water. Long, finger-like processes are pushed out, the ends of which develop first a longitudinal and then a transverse groove, and finally become changed into typical Maltese crosses. The whole is anisotropic. These figures are really crystals in fluid form; they have been called fluid crystals. By the end of twenty-four hours it was found that the cholesterol crystals had completely disappeared, being entirely converted into the ester form. *Under the polarizing microscope the newly-formed ester was very similar in appearance to the lipoid material of the strawberry gall-bladder.* We are now, therefore, in a position to say with a considerable degree of confidence that the yellow material of the strawberry gall-bladder is the ester of cholesterol with a fatty acid.

The polarizing microscope forms a ready and convenient method of examining lipoid deposits. It at once distinguishes between the glycerin and the cholesterol series of fats. The uncertainty which sometimes accompanies the staining of fats is not encountered in the method. It has, however, its drawbacks. Precise orientation is difficult owing to the darkness in which the greater part of the section is shrouded, so that it is not possible to be certain if the lipoid is in the epithelial cells or in the stroma.

Moreover, all that glitters is not cholesterol. It was soon found, for example, that fibrous tissue appeared quite bright (not brilliant), although muscle was lost in impenetrable darkness. No explanation can be offered why a non-crystalline substance like fibrous tissue should, even though feebly, refract polarized light.

The phenomenon suggests that the method might prove of value in histological work along other lines.

4. **Closed Diaphragm.**—The lipoid in the gall-bladder can be demonstrated without the use either of special staining methods or of the polarizing microscope. When a frozen section of a strawberry gall-bladder is examined under an ordinary microscope with the diaphragm well closed, the lipoid is seen as dark, almost black masses. Under the high power the acicular crystals can be seen with great distinctness, and the amorphous granular masses can also be made out.

This method, in addition to its simplicity, has the advantage that it obviates the possibility of error due to deposits of such a stain as Scharlach R. When, however, the lipoid is small in amount or scattered diffusely, staining methods are required for its detection.

5. **Microchemical Reaction.**—The behaviour of the lipoid in the mucosa when viewed under Nicol's prisms suggested very strongly that it must be an ester of cholesterol. It was felt, however, that even more convincing proof might be obtained if one of the chemical reactions for cholesterol could actually be carried out in the tissues. This was manifestly impossible in the case of most of the tests, but it was felt that Moleschott's sulphuric acid reaction might possibly be applied to a section of the tissue.

When concentrated H_2SO_4, in the proportion of five of the acid to one of water, is added to cholesterol crystals, the latter turn a bright carmine red. The reaction with the ester of cholesterol is not mentioned in the literature, so a film of the ester was prepared, and the concentrated acid added. The resulting colour was a terra-cotta brown. When the reaction was watched under the polarizing microscope an interesting phenomenon was observed. The cholesterol crystals remained as brightly anisotropic as before, but the ester completely lost its power of refraction. The difference could be observed very beautifully when a mixture of the crystals and the ester was used.

The test was then applied to the tissue. A frozen section of a gall-bladder containing lipoid was floated on to a slide and allowed to dry; it was gently blotted with filter paper; the acid was then added, and a cover-glass applied. The result was highly gratifying. The lipoid rapidly became stained, first yellow, then brown, and finally, after a considerable time it acquired a faint tinge of violet or purple. Perhaps the dominant colour should be described as henna rather than brown. It closely resembled the colour produced by the action of the acid on cholesterol ester. Moreover, the anisotropic character of the lipoid was completely destroyed by the action of the acid. In short, the lipoid gave the chemical and physical reactions of cholesterol ester. It was feared that the strong acid would have a disastrous effect upon the tissue, but even the epithelial cells remained undamaged. In the earlier experiments the changes in the tissues were largely obscured by a tremendous evolution of bubbles, due apparently to a union of the concentrated acid with a small amount of water left in the tissue even after blotting, with the evolution of gas. It was soon found that this could be overcome by first allowing a gentle stream of acid to flow over the section, and after all the bubbles had been produced and removed, then to apply the cover-glass.

Here, then, was a chemical test for cholesterol ester which could be applied to any tissue, and it was felt that a powerful new instrument of investigation had been put in our hand, an instrument which could be applied to other tissues in an investigation into the rôle which cholesterol plays in the animal organism.

The method was at once applied to an organ which is known to be rich in cholesterol, namely, the adrenal cortex, and the result was exactly as had been anticipated. The cortex at once took the brown colour, whereas the medulla remained unstained. The value of the method was thus confirmed in a striking manner.

III. AMOUNT OF CHOLESTEROL IN STRAWBERRY GALL-BLADDER.

Another problem now presents itself. Is the increase in cholesterol in the strawberry gall-bladder real or only apparent? In fatty degeneration of the heart or of the kidney a large amount of fat can be demonstrated by staining methods in the heart muscle fibres and in the epithelial cells of the convoluted tubules. But when a quantitative estimation of the fat extracted from the organ by means of a Soxhlet apparatus is made it is often found that the amount is no greater than that in a normal heart or kidney. The invisible fat normally present in a combined form has merely become visible owing to the pathological changes induced by the toxic agent. The increase in fat is apparent, not real.

In order to determine this point, extractions were made of a number of strawberry gall-bladders, and of a normal gall-bladder as a control (only one of the latter removed at operation was available). The mucous membrane was separated from the fibrous coat, dried, and a weighed portion of each was extracted with a mixture of equal parts of absolute alcohol and ether in a Soxhlet extractor. The ethereal extract containing the lipoid was evaporated almost to dryness and the residue dissolved in chloroform. The amount of cholesterol in the chloroform solution was then estimated by developing the characteristic green colour of the Liebermann-Burchard reaction through the addition of acetic anhydride and concentrated sulphuric acid, comparing in a Bausch and Lomb colorimeter the colour produced with that of a solution of cholesterol of known strength treated in the same way. The figures obtained in a series of observations are given in *Table I.*

Table I.—Showing varying Cholesterol Content of the Gall-bladder in different Conditions.

Type of Gall-bladder	Per Cent Cholesterol by Weight
Normal - - -	0·51
,, - - -	1·70
Inflamed (no lipoid)	0·36
Strawberry No. 1	60·54
,, ,, 2	46·40
,, ,, 3	34·60
,, ,, 4	50·45
,, ,, 5	51·00
,, ,, 6	41·80

It will be seen that the mucosa of the strawberry gall-bladder contains an enormous amount of cholesterol compared with that of the normal organ. The increase is therefore real and not merely apparent. It is interesting to note that the fibrous coat shows little or no change.

IV. DISTRIBUTION OF THE LIPOID.

The discussion so far has been confined to the strawberry gall-bladder, to the gall-bladder, that is, in which the lipoid is visible to the naked eye. The material for the present part of the investigation consists of the gall-bladders removed during 1921 and the first half of 1922, 100 in number. All of these were examined for lipoid by the methods already described. It was soon discovered that lipoid may be present although none is visible to the naked eye or even under the low-power binocular microscope. It was found in 52 cases out of the 100; in only 10 of these was the lipoid discernible by the naked eye.

The term 'strawberry gall-bladder' is sometimes used as if it were a definite pathological entity such as acute cholecystitis. From the above remarks it is evident that this is not so. Under certain pathological conditions, presently to be discussed, an ester of cholesterol is formed in the mucosa of the gall-bladder. When this formation is so marked in degree that the lipoid becomes visible to the naked eye, the condition of strawberry gall-bladder is present. It is all a question of degree. The term 'lipoid gall-bladder' is suggested; this would include both the strawberry gall-bladder and those gall-bladders in which the lipoid is not visible to the naked eye.

The lipoid is usually scattered over the entire surface of the mucosa. Not all the ridges are involved, nor is every part of a ridge; the distribution is essentially discrete. Occasionally only one portion of the gall-bladder is involved. In one very instructive

Table II.—Showing how the Cholesterol Content may vary in different Parts of the same Gall-bladder.

	Mucosa	Fibrosa
Part showing advanced inflammatory changes	16·30 per cent	0·10 per cent
Part showing slight inflammation but marked strawberry appearance	41·80 per cent	0·17 per cent

case (*Table II*) the organ could be divided into two portions of unequal size. About one-third, including the neck, was comparatively slightly thickened, the ridges were tall, thin, and normal-looking, but there were numerous large deposits of lipoid. The other two-

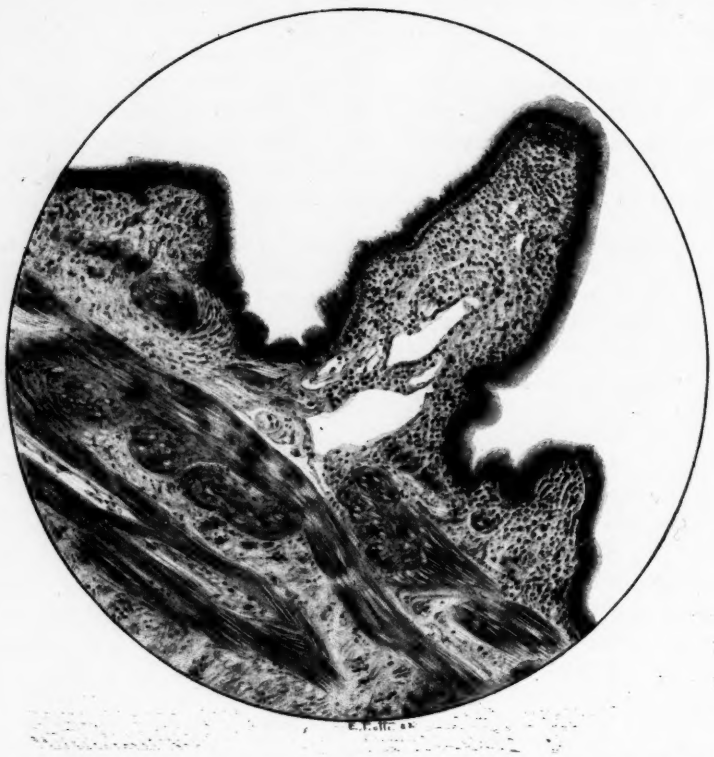


Fig. 280.—Lipoid at the base of the epithelial cells, and to a slight extent in the stroma.

thirds, including the fundus, was markedly thickened, the ridges were low, thick, and quite pathological; an inflammatory process had evidently been in progress for a considerable time, but not a trace of lipoid could be seen under the low-power microscope. This suggests very strongly that the deposit of lipoid is an early phenomenon in the disease-process, and that it may disappear—at least to the naked eye—at a later date.

Villi.—In microscopic sections the lipoid is invariably most abundant in the villi—that is to say, the ridges seen on cross-section. It may be present in the epithelium of the surface, in the stroma of the villi, or in both. The *epithelium* may be loaded, but more frequently a narrow line, stained bright red in Scharlach R preparations, is seen running along the base of the cells, the entire deposit being proximal to the nucleus (*Fig.* 280). The deposit is more marked in the epithelium covering the villi than in that lining the intervening depressions. Indeed, one sometimes gets the impression that the villi are projecting upwards in order to collect or to absorb as much cholesterol as possible.

The *stroma* of the villi, that is to say the substance of the mucous membrane (what has been called the submucosa by some writers), although consisting mainly of loose connective tissue, always contains mononuclear cells, which are present in great numbers in conditions of inflammation (***Fig.*** **281**). The lipoid is usually contained within these cells, imparting to them a granular appearance. In other cases it is completely extracellular. Frequently the two forms are combined. As a rule, when there is lipoid in the stroma it is also present in the surface epithelium, but in occasional specimens it was confined entirely to the stroma. Sometimes a trail of lipoid could be traced from the epithelium into the depths of the stroma, and down to the base of the villi. It almost appeared as if a snail had crawled down the villus, leaving a track of lipoid behind it.

FIG. 281.—Gland-like formation often seen in chronic cholecystitis. Infiltration with round cells is also well shown.

In some cases the *endothelium of the blood-vessels* contained streaks of material which stained red with Scharlach R. This interesting observation suggested the possibility that the lipoid might be absorbed into the blood-vessels. Careful search was therefore made for the presence of droplets of lipoid actually in the lumen of the vessel. These were never observed in the capillaries of the villi, but in two cases they were found in the vessels of the muscular coat. Too much stress must not be laid upon this remarkable finding, for the lipoid was only seen in Scharlach specimens, and as the tissue has to be treated for a few moments with alcohol, it is possible that some lipoid may have been transported so as to lie over the lumen of the vessel. The only convincing proof would be to demonstrate the lipoid within the lumen by means of the polarizing microscope, but owing to the difficulty of orientating the specimen when viewed by polarized light this is hardly possible. In one of the cases the lumen of the vessel appeared to be distinctly distended by the lipoid globulin, so the evidence, although not conclusive, is nevertheless suggestive.

The Fibrous Coat.—Although the lipoid is always most marked in the mucosa, and is frequently confined to that layer, it may also be found in the fibromuscular coat. Again it may be either intra- or extracellular. It is contained within cells which are of chronic inflammatory origin. Some of these are rounded or more often polygonal in form

(*Fig.* 282). Lipoid is best seen in this region where, as the result of long-continued inflammation, the wall of the gall-bladder has become converted into a mass of organizing granulation tissue containing large numbers of young fibroblasts. These cells are often loaded with lipoid material. The occurrence of lipoid in the endothelium of small blood-vessels has already been referred to.

The extracellular lipoid may take the form of small granular masses, but not infrequently it is seen as narrow linear streaks, which may run at any angle to the surface. The appearance suggests that the lipoid is confined within tissue spaces or lymphatics, much as are the lines of epithelial cells spreading by a process of permeation from a carcinoma of the breast.

FIG. 282.—Inflammatory cells packed with lipoid granules. High power.

Lipoid occurs in the depths of the gall-bladder under circumstances somewhat different from those which accompany its appearance in the mucosa. In the former case the wall is always the seat of advanced inflammatory changes, in the latter there may be so little change that the mucosa might otherwise pass for normal. In other words, the occurrence of lipoid in the mucosa is an early change, whilst in the fibrosa it appears at a much later stage.

To summarize the observations on the distribution of the lipoid. It may be found in any of the coats and at any depth. Its most common place of occurrence is the surface epithelium and the stroma of the villi. It is seldom found deep to the mucosa unless within chronic inflammatory cells.

V. WHAT IS THE CAUSE OF THE LIPOID DEPOSIT?

Now that the nature of the lipoid has been determined, and its distribution in the gall-bladder wall discussed, it is a pertinent question to ask what causes it to be deposited. A final answer to that question cannot be given at the present time. Experiments are in progress the object of which is to produce the lipoid deposits in animals under known conditions. But until success attends these efforts the answer can only be surmised.

The most probable factor is inflammation. In a study of the 52 cases in which lipoid was present inflammatory changes were found in every case. But the inflammatory changes were seldom marked, and were sometimes so slight in degree that it was difficult to be sure whether or not they were present. The changes were sometimes confined to the mucosa; at other times they extended into the deeper coats. The principal feature was a collection of the cells associated with chronic inflammation, namely, lymphocytes and plasma cells. Occasionally no inflammatory cells could be discovered, but presence of vascular dilatation and extensive œdema in the loose stroma of the villi indicated the action of some irritant.

When the inflammation becomes more severe in character, and especially when it reaches the stage of suppuration, the lipoid is no longer found. Can it be possible that, after being deposited, it has subsequently disappeared? One case already referred to suggests this possibility. The greater part of the gall-bladder was thickened and had evidently been the seat of inflammation for a considerable time. It showed no trace of lipoid. The remaining portion was much thinner, the mucosa was much less altered, but there were extensive deposits of lipoid. Such a case suggests that the early stage of inflammation, or it may be the milder forms of that process, are characterized by the deposition of lipoid, but as the inflammatory process progresses the lipoid disappears owing to some mechanism at which we can hardly even guess. The kidney offers some sort of analogy: in the early stages of nephritis the epithelial cells show an abundant deposit of fat, whereas in the stage of chronic interstitial nephritis this may have completely disappeared. The analogy, of course, will not bear too close a scrutiny.

It is somewhat different in the case of the deeper coats. Long-standing inflammation of the fibrosa, as evidenced by the presence of great numbers of fibroblasts, may be accompanied by extensive lipoid deposits within the inflammatory cells.

It must be admitted that the demonstration that the deposit of lipoid is associated with a certain degree of inflammation is in reality no explanation. We are still completely in the dark as to why the lipoid should be deposited. In a later part of this paper the relation of the gall-bladder to the cycle of cholesterol in the body will be considered. At this stage it may be suggested that if cholesterol should chance to be absorbed from the bile and to pass into the wall of the gall-bladder, any inflammatory or other process which interferes with that absorption may result in the cholesterol being deposited, first in the surface epithelium and later in the deeper parts, either in the form of free cholesterol or of an ester formed by the union of cholesterol with a fatty acid. Should the villi be specially concerned in the process of absorption, then the deposits would be most pronounced in those structures.

These are but guesses at the truth. Not until the deposition of lipoid has been produced experimentally in an animal will it be possible to state with certainty the factors which govern the formation of these deposits.

VI. RELATION OF LIPOID TO GALL-STONE FORMATION.

The etiology of cholelithiasis is a subject regarding which great uncertainty still prevails. A gall-stone is composed of the several constituents of the bile combined in varying proportions. One or more of these may be absent. Indeed, only one may be present, as in the pure cholesterol stone, the cholesterol-free stone found in hæmolytic jaundice, etc. In view of these facts it is but natural that the attention of investigators should have been fixed entirely on bile in the attempt to determine the factors which govern the formation of calculi.

Three principal factors are held to be responsible for the production of gall-stones: (1) *Stasis of the bile;* (2) *Infection of the bile with micro-organisms;* and (3) *An increase in the cholesterol content of the bile.*

1. **Stasis of the Bile.**—This may occur as a result of a variety of conditions, such as obstruction, interference with the innervation of the gall-bladder, muscular atony, etc.

2. **The Presence of Micro-organisms in the Bile.**—This is an important factor in determining the precipitation of substances usually held in solution. This has been

shown by many investigators. When a specimen of bile is inoculated in vitro with a culture of *B. coli*, precipitation of the cholesterol and of the bile salts occurs. This precipitation is probably due to interference with the bile salts, upon the presence of which the solubility both of the cholesterol and of the bile pigments depends.

A clear distinction must, however, be drawn between infection of the bile and infection of the wall of the gall-bladder. Just as it is frequently possible to find bacteria in the synovial membrane of a joint in cases of chronic synovitis when none can be detected in the synovial fluid, so bacteria may be present in the wall of the gall-bladder when none can be found in the bile. Rosenow[2] has shown that in order to determine the existence of bacterial infection of the gall-bladder the wall of the bladder must be pounded up and added to the culture medium, the bile itself often being quite sterile. Finkelstein, working in our laboratory, has demonstrated the same absence of bacteria from the bile in many cases of mild cholecystitis, strawberry gall-bladder, and biliary calculi. When, therefore, we speak of infection as a factor in the production of gall-stones we should think of the bladder wall rather than of the free bile.

FIG. 283.—Polypoid mass of cholesterol ready to separate. Early case of strawberry gall-bladder. Stained with Scharlach R.

3. **The Cholesterol Content of the Bile** is doubtless an important factor in the production of calculi. Two of the conditions most frequently associated with calculus formation, namely, typhoid fever and pregnancy, are characterized by a great increase in the cholesterol content of the blood and therefore of the bile. But here again the danger in the past has been to overlook the importance of the gall-bladder itself. As we have already shown, the wall of the gall-bladder may, under certain conditions, present an increase of the cholesterol content beside which any increase in the cholesterol in the bile fades into insignificance.

It seems justifiable, therefore, to attempt to direct attention from the bile to the gall-bladder itself as the most important factor in calculus formation, at least in the early stages. And it is the early stage which is all-important. Once calculus formation has been started, the growth of the stone may be due to the deposition of material from altered bile.

A study of the material at our disposal leads one to the belief that the initial step in calculus formation is to be found in the wall of the gall-bladder itself, and consists in the deposition of a lipoid in the form of cholesterol ester in the gall-bladder mucosa. A glance at *Fig.* 283 will show that as this deposit of lipoid increases in bulk, the villus in which it

is contained may develop more and more into a papillomatous-like process, the stalk of which finally becomes so attenuated that separation is inevitable. When that occurs we have a foreign body composed of cholesterol and albuminous material, lying in the cavity of the gall-bladder, and forming an ideal nucleus for the formation of further deposits.

Whether or not this further formation will occur depends on a variety of circumstances. The factors which make for the formation of gall-stones are apparently periodic rather than continuous in their mode of action. A collection of gall-stones from one case seldom shows a great variation in size and type. As a rule all the stones are of about the same size, as if formed at the same time. In some cases, it is true, there may be variation, but this is usually variation of one whole set as compared with another set. For instance, in one of our cases there were three distinct sets of calculi in the gall-bladder, with about half a dozen stones in each set. The first were large, the second medium, and the third very small, but all those of the same set were exactly the same size. The initial factor which started the stone formation must have come into play three times.

The two factors most liable to periodic fluctuation are the cholesterol content and infection. The cholesterol content of the blood and of the bile, for instance, will rise with each pregnancy, only to fall to normal in the intervals. Infection, again, is probably often periodic. The kidney in Bright's disease, the heart valves in endocarditis, may be the seat of recurring infections, with each of which the organ is left more and more damaged. So also with the gall-bladder. The profoundly altered gall-bladders which we often encounter are not as a rule the result of a single infection, but represent the cumulative effect of many such attacks. The infection, however, is one which affects the gall-bladder wall rather than the bile.

From the above considerations it is apparent that there are several things to be said in favour of the view that the starting-point of a calculus may be the wall of the gall-bladder. It is interesting to note that in a book by Chauffard[3] just published the author arrives at a somewhat similar conclusion. Small biliary calculi were found to originate inside the villi as minute collections of cells surrounded by cholesterol. These are shed, grow, and ultimately become faceted. Dewey[4] has succeeded in producing gall-stones in one rabbit by means of long-continued injections of cholesterol. When these were embedded in paraffin by the method of Aoyama,[5] sectioned, and the sections stained with methylene blue, it was found that disintegrated cells formed the framework of these stones. Dewey considers that these represent desquamated cells ; but it is more probable that they are epithelial cells of the surface in which the cholesterol was first deposited, and the cells subsequently shed.

It in no way follows that this is the only method of calculus formation. Indeed, when one looks at the calculi collected from a large series of cases, the variations are seen to be so extreme that one shrinks from being in any way dogmatic about the possibilities of their formation.

VII. THE CLINICAL SIGNIFICANCE OF LIPOID DEPOSITS.

The surgeon of course asks : What is the clinical significance of these deposits of lipoid in the gall-bladder mucosa ? What is the meaning of the strawberry gall-bladder, and how may it be recognized clinically ? This is a difficult question to answer, for the problem is not a clear-cut one. If the strawberry gall-bladder formed a definite separate clinical entity, it would be easy to go through the histories of such cases, and arrive at some fairly satisfactory conclusion. Unfortunately, as has already been pointed out, there is no such disease as a strawberry gall-bladder : there are all degrees of lipoid deposit, from the cases in which the strawberry appearance is most pronounced to those in which the lipoid is invisible to the naked eye ; and finally there may or may not be present such a complication as calculi, which may completely overshadow any symptoms which might be characteristic of the deposition of lipoid.

The only safe method is to select those few cases of typical strawberry gall-bladder in which no complicating factors are present. A brief summary of three such cases may be given.

Case 1.—Mrs. W., age 30, weighing 160 lb., has suffered for ten months from what she described as pulling and drawing sensations in the epigastrium. She never had an acute attack of pain, nor was jaundice present at any stage of the illness. Nausea was a prominent symptom. After partaking of a few mouthfuls of food she feels as if she could eat no more. It seems to her that food is unable to pass the stomach. She does not complain of acid eructations or belching of gas. There is no periodicity to the sensation of abdominal discomfort, nor does food afford her any relief. Duodenal drainage by Dr. Finkelstein showed numerous pus cells in the gall-bladder bile, but no micro-organisms. At operation the gall-bladder appeared almost normal, apart from some slight thickening and opacity.

Further examination revealed an extreme condition of strawberry gall-bladder. There were enormous deposits of lipoid in the form of doubly refractive acicular crystals, and giving a marked reaction with the sulphuric acid test, throughout the whole of the mucosa. There were slight inflammatory changes both in the mucosa and the fibrous coat, but it is difficult to account for the presence of pus cells in the bile obtained by the duodenal tube.

Case 2.—Mrs. S., age 43, weighing 165 lb., complained of pain in the epigastrium and the right side of the abdomen. The present attack commenced shortly after labour three weeks ago. During the last few months she has had two similar attacks. The pain is usually localized to the right hypochondrium, but is sometimes referred posteriorly to the area between the scapulæ. Food appears to stick in the epigastrium. For about an hour after a meal she belches gas. She feels better when hungry. The type of food and the size of the meal appear to make no difference.

The gall-bladder when removed was very slightly thickened and contained no stones. Only small patches of lipoid could be seen here and there on the surface of the mucosa. Sections, however, showed an abundant deposit of lipoid in the epithelial cells, and to a lesser degree in the stroma of the villi. It was even present in the walls of the blood-vessels. The mucosa was crowded with inflammatory cells, and the low-power binocular microscope showed the ridges to be so swollen as to remind one of the convolutions of the brain.

Case 3.—Mrs. S., age 50, weighing 190 lb., has suffered from severe digestive disturbance over a period of two years. She has never had any violent attacks of pain such as might suggest the passage of a calculus, but the pain has been sufficiently distressing in character, and there is marked tenderness over the gall-bladder. She has never been jaundiced. At operation the gall-bladder appeared so normal that the surgeon hesitated some time before removing it.

When the gall-bladder was opened the entire inner surface was seen to be studded with the yellow specks characteristic of lipoid deposits. The summits of the ridges were thickened and loaded with lipoid, but the sides were thin and apparently free. No stones were found, but there was one large, yellow, papillomatous process. Sections showed enormous deposits of lipoid in the stroma of the villi, little in the epithelium, and a considerable quantity in the fibrous coat. No inflammatory cells were observed, but the small vessels of the mucosa were congested, and an extensive œdema of the villi formed a striking feature of the microscopic picture.

Summing up this part of the subject, these cases showed fairly characteristic symptoms of cholecystitis without calculus formation; they were all distinguished by marked deposits of cholesterol ester, although without the formation of stones. The question as to why these pathological changes in the gall-bladder should produce, or at least be associated with, these gastric and other symptoms is one which the present writer does not feel himself qualified to discuss. In any case the explanation of the mode of production of symptoms in gall-bladder disease is often a matter of extreme difficulty. On this day of writing I was present at an operation for removal of the uterus because of fibroids; sweeping his hand round the abdomen the surgeon discovered that the gall-bladder was literally packed with stones, and much fibrosed as the result of long-standing inflammation; and yet this patient had never had even a suggestion of symptoms pointing to disease of the gall-bladder.

VIII. THE COMPARATIVE ANATOMY OF THE GALL-BLADDER.

One of the most curious facts about the gall-bladder, and one which presents itself as a stumbling-block in the way of any explanation of its function, is the absence of the organ in a number of animals. Amongst the animals mentioned by McMaster as having no gall-bladder are the horse, the deer, the rat, the pocket gopher, the dove, and the peccary. Why the mouse should possess a gall-bladder, but not the rat; the pocket gopher, but not the striped gopher; is certainly a knotty problem to solve.

Our investigations on the gall-bladders of animals commenced in an endeavour to determine the histology of the normal gall-bladder. As already mentioned, autopsy

material proved quite unsuitable, and the surgeons were not presenting us with normal gall-bladders.

Sections were accordingly cut of the fresh gall-bladder of a dog ; they were cut on the freezing microtome and stained with Scharlach R, simply because that was the routine method we employed. Naturally we expected to find a normal mucosa without a trace of lipoid. Picture our surprise when, on looking down the microscope, we found that the surface epithelium was packed with lipoid which stained a brilliant red. The question at once arose : Was the presence of lipoid in the gall-bladder of the dog a normal occurrence, or was it a manifestation of disease ? In order to answer this question a series of dogs was examined, and observations were made on a number of other animals.

The Dog.—Fifteen dogs were examined. In no case did the gall-bladder show any evidence of inflammation. In every case lipoid was present in the mucosa, although varying in amount in different animals. It was always confined to the epithelium, and was never observed in the stroma. Moreover, the distribution in the epithelium differed from that of the lipoid of the strawberry gall-bladder in man. It invariably occupied the distal part of the cell, so that the nucleus was closely pressed against the base of the cell. In man, on the other hand, the lipoid was usually proximal to the nucleus. The largest deposits were in the tips of the villi, and the deposit was often scanty or absent in the depressions between the ridges. In two cases the reaction with Nile blue sulphate is worthy of note. Instead of the dark blue or violet colour characteristic of cholesterol ester, the lipoid took on a rose pink somewhat resembling that of the neutral fat in the subserous coat.

The behaviour of the lipoid under crossed Nicol's prisms was peculiar and perplexing. In some cases it appeared, as might be expected, in the form of brilliant white masses. Moreover, bright Maltese crosses were frequently seen adhering, so it seemed, to the surface of the villi. In the other cases, however, the material, which had stained so brilliantly with Scharlach, now appeared merely as a dull grey, and sometimes not at all. It really seemed as if the lipoid varied in its physical characteristics in the different cases. With the closed diaphragm it had a dull grey colour. No evidence of yellow lipoid could be seen either with the naked eye or by means of the low-power binocular microscope.

At one stage of the investigation it was thought that the lipoid might bear some relation to diet, for it seemed to be more abundant in those animals which were poorly nourished. The matter was put to the test of experiment. A small piece of the gall-bladder was removed from a normal dog of average nutrition. The animal was then given nothing but water for seven days. At the end of that time another piece of the gall-bladder was removed. The dog was now placed on a full diet for a week, when it was killed, and the gall-bladder removed. The specimens were stained for lipoid, but exactly the same amount was found in all three. Diet, therefore, appeared to have no effect on the lipoid content of the mucosa.

In two cases masses of lymphoid tissue were encountered in the mucosa. These were similar in form and general appearance to the lymphoid follicles of the appendix. It was noticed that the epithelium covering these nodules was free from lipoid. Similar structures are never found in the human gall-bladder.

In one dog, used in experiments on the absorption of iron to be described presently, a remarkable appearance was observed. The gall-bladder was removed after it had been injected with a 2 per cent solution of potassium ferrocyanide. The mucosa was found to be studded with small green bodies, which resembled green peas under the dissecting microscope. The contents were fluid or slightly gelatinous. Microscopic sections showed that the little bodies were vesicles or cysts in the substance of the mucosa. They were not found in any of the other dogs in which potassium ferrocyanide was injected into the gall-bladder.

The Cat.—The gall-bladders of five cats were examined. Lipoid was present in two, absent in three. When present it presented quite a different picture from that seen in the dog. It was scanty in amount, took the form of minute droplets, and was confined to that part of the epithelial cell proximal to the nucleus. In the dog it was always distal to the nucleus. It was only with great difficulty that it could be seen with the

polarizing microscope, but several Maltese crosses were observed adhering to the surface of the villi.

Specimens of the kidney, the liver, and the adrenal were also examined for fat. The adrenal cortex, as might be expected, was loaded with cholesterol ester. Both the liver and the convoluted tubules of the kidney contained a large amount of material which stained red with Scharlach R. In the liver this material was brilliantly doubly refractive, but in the kidney not at all. This suggests that in the kidney the red-staining material was a glycerin fat, in the liver a cholesterol fat.

Other Animals.—The gall-bladder of the cow, the rabbit, the guinea-pig, and the frog were examined. In none of these was any lipoid found.

IX. THE FUNCTION OF THE GALL-BLADDER.

In the history of medicine it has happened not infrequently that pathological investigations have thrown valuable light on the physiology of an organ. The case of the pituitary body and the localization of cerebral function are examples which at once suggest themselves. The same may prove true for the gall-bladder.

The function of the gall-bladder forms at present a favourite subject for discussion in surgical journals. We do not propose to review, as is often done, all the suggestions which have been put forward at various times. The gall-bladder is certainly not a mere reservoir for the bile, for its capacity is little more than one ounce, and it is probable that the daily production of bile amounts to nearly a litre. It has been suggested that a prime function of the gall-bladder is to convert the continuous flow from the liver into an intermittent flow into the duodenum. This view is strengthened by a consideration of the fact that the lower end of the bile-duct is guarded by a sphincter (the muscle of Oddi) which relaxes in response to the demands of digestion, so that a considerable volume of bile can flow into the duodenum at the very moment when it is most needed.

This simple view entirely fails to explain certain facts which cannot be ignored. The recent experimental work of Rous and McMaster[6,7] has shown that the gall-bladder exerts a most remarkable concentrating effect on the bile which passes through it. In some instances the bile was concentrated as much as ten times. A simple reservoir does not concentrate the fluid which is contained within it.

Moreover, a study of the structure of the gall-bladder at once disposes of the idea that it is intended to play merely a passive rôle, such as that of the urinary bladder. A study of the structure of a part will often enable one to make a shrewd guess at the corresponding function. Thus the glands of the stomach suggest secretion, the glands and villi of the small intestine suggest both secretion and absorption, the glands of the large intestine lined by cells containing mucin suggest the secretion of mucus. But the best idea of the essential features of the wall of the gall-bladder is to be obtained, not from microscopic sections, but from a direct view by means of the binocular dissecting microscope. The picture revealed by that instrument has already been described in some detail; it differs absolutely from the flat, featureless wall of the urinary bladder. The tall, graceful, delicate folds, thin as gossamer, covered by a highly specialized columnar epithelium, and plentifully supplied with blood-vessels, are surely designed for one purpose, namely, absorption.

Microscopic sections tend to confirm this view. The delicate villi with thin-walled vessels running down the centre can play no part in a reservoir. They are constructed for absorption. The morphological evidence, however, shows that something is contributed by the gall-bladder to the bile. In a number of cases of mild inflammation the epithelial cells of the surface have been so distended with mucin as to become veritable goblet cells. A subsidiary function of the gall-bladder therefore appears to be the production of mucus, a function which, as might be expected, is called into increased activity in conditions of catarrhal inflammation.

It is sometimes stated, even in well-known monographs dealing with the gall-bladder, that the mucosa is studded with glands. This is not the case. In chronic cholecystitis,

however, the depressions between the villi become deepened and tortuous, until their connection with the surface may appear to be cut off, so that they may be mistaken for glands, an error made all the more possible by the occasional distention of the cells with mucin.

In order to confirm or disprove the idea suggested by anatomical considerations a series of experiments was undertaken with the object of determining, first, whether absorption really does occur, and second, what is the constituent of the bile which is absorbed.

Absorption of Iron.—The method employed for solving the first problem was the demonstration of the Prussian blue reaction in the wall of the gall-bladder after the injection of an iron salt into the lumen. The abdomen of a dog was opened, a fine needle introduced into the gall-bladder, the bile withdrawn, and an equal quantity of a 2 per cent solution of iron ammonium citrate injected. A series of dogs was used, and at varying intervals of time after the injection the gall-bladder was removed. In some cases the animal was kept under the anæsthetic, in others the abdomen was closed, and the animal allowed to live for twenty-four hours.

As soon as the gall-bladder was removed it was opened, the surface washed free of bile and the iron salt, and the specimen placed in a fixative to stop any diffusion of the iron. Pure formalin, 10 per cent formalin, and 95 per cent alcohol were used. The best results were obtained with pure formalin. The fixative contained in addition a 2 per cent solution of potassium ferrocyanide and 1 per cent hydrochloric acid. If absorption of the iron had taken place the Prussian blue reaction, as evidenced by the appearance of blue granules, would be observed within the wall of the gall-bladder.

The earlier experiments were inconclusive, partly owing to the diffusion of the iron throughout the wall, partly to the formation of blue deposits of mucoid material on the surface. When, however, pure formalin was used as a fixative, and when the surface of the mucosa was washed thoroughly clean before the fixative was used, the results were clear and decisive. Even after so short a time as half an hour there were numerous blue granules in the epithelial cells, and to a lesser extent in the stroma of the villi. None were seen in the deeper layers, nor was there any indication as to whether the iron was absorbed into the blood-vessels or lymphatics.

A recent observation by Harer, Hargis, and Van Meter throws light upon this question. These workers introduced a hypertonic solution of potassium sulphocyanide into the gall-bladder of a dog through a ureteral catheter passed up through the ampulla of Vater. Lymph was collected in capillary tubes from the lymph channels in the wall of the gall-bladder, and tested with ferric chloride. Positive results were obtained within a very short time after injection. This experiment suggests not only that the gall-bladder possesses ready powers of absorption, but also that the absorbed material passes into the lymphatics.

Absorption of Cholesterol.—Granted that absorption may occur from the gall-bladder, the question arises: What is absorbed?

From the work of Rous and McMaster[2] we have every reason to believe that water is absorbed. These investigations have shown that the bile becomes concentrated to a remarkable degree after a brief sojourn in the gall-bladder. So great is the absorptive power of the mucosa that this concentration can be shown when the bile is allowed merely to flow through the gall-bladder, without being kept there. Of the solid constituents of the bile (bile salts, bile pigments, cholesterol, and lime), the substance with which we are specially concerned is cholesterol. Is there any evidence that cholesterol is absorbed by the gall-bladder?

Before this question can be answered it is necessary to consider briefly the part played by cholesterol in the animal economy. Here again we are more familiar with the pathological manifestations of the subject than with the behaviour of cholesterol in health. Deposits of cholesterol are found in arteriosclerotic blood-vessels, in the white spots of albuminuric retinitis, in xanthoma, and in the kidney tubules in cases of nephrosis. The blood cholesterol is raised in pregnancy, convalescence after typhoid fever, chronic

nephritis, nephrosis, diabetes, jaundice, and many cases of cholelithiasis. It is lowered in acute infections (with the notable exception of typhoid) and in tuberculosis.

Cholesterol, isolated from gall-stones by Conradi in 1775, and fully examined as to its chemical constitution in 1815 by Chevreul, who first gave it its name of cholesterin (now usually changed to cholesterol to indicate its alcohol-like character), is a monatomic alcohol which, on account of its solubility in fat solvents, is regarded as a lipoid. It is widely distributed in the animal and vegetable kingdoms, occurring in the latter in the form of an isomer named phytosterol. It is found in abundance in blood, bile, sebum, the white matter of the brain, the medullary sheath of nerves, the cortex of the adrenal, and the corpus luteum of the ovary.

As already indicated, our information regarding the physiology of cholesterol has not kept pace with the advances in our knowledge of its behaviour under pathological conditions. The chief contributions have been made by a single set of English workers, Dorée, Ellis, Fraser, and Gardner,[9] in a series of papers published in the Proceedings of the Royal Society between 1908 and the present year. Their work has consisted in feeding animals with cholesterol and estimating the variations in the blood cholesterol and the amount of cholesterol excreted in the fæces.

The cholesterol in the fæces should theoretically be derived partly from the food, partly from the bile. Dorée and his associates found that the cholesterol in the fæces of the dog amounted to only one-fifth of the total which might be expected from these sources. Moreover, the cholesterol in the fæces could be entirely accounted for by the cholesterol in the food. That in the bile had apparently been absorbed; that it should have been destroyed is unlikely, owing to the very stable nature of cholesterol. The cholesterol of the bile, therefore, is absorbed, excreted, and reabsorbed once more. The truth of this cholesterol cycle is recognized in the title of a recent book by Grigaut.[10]

The question is, where does this absorption occur? It is here suggested that some, at least, is absorbed by the gall-bladder. The evidence in support of this view is by no means conclusive, but some experimental work, at present only in the initial stage, will, it is hoped, throw light on the subject. The following evidence is also worthy of consideration.

1. Under certain pathological conditions cholesterol is deposited in the wall of the gall-bladder. But is this cholesterol on its way in or on its way out? Is it being absorbed or is it being excreted? This question can hardly be answered on purely morphological grounds. The anatomical arrangements already discussed, however, suggest absorption rather than secretion. The occurrence of cholesterol in the connective-tissue cells of the mucosa, and possibly in the lymphatics, hardly suggests a process of excretion. Naunyn was of the opinion that all the cholesterol in the bile was produced by the gall-bladder mucosa. In this he was undoubtedly wrong. Adami considers that, as usual, the truth lies midway between the two extremes, and that part of the cholesterol is produced by the liver, part by the gall-bladder. It must be admitted that the fact that cholesterol which may be passing inwards through the wall of the gall-bladder is deposited in conditions of disease does not constitute a proof that such absorption occurs under normal conditions; but it points in that direction.

2. The injection experiments of Dewey are also of interest. This observer found that, as the result of long-continued injections of cholesterol, deposits of that substance were found in the liver and kidney of the rabbit. In some cases large deposits of a material which, although not anisotropic, yet stained red with Sudan III and purplish-blue with Nile blue sulphate, were found in the mucosa of the gall-bladder. This substance, which occupied the centre of the villus, he considers to be a cholesterol compound without anisotropic properties. He is of opinion that the material was situated within the lymphatics. If this is correct the cholesterol must almost certainly have been absorbed from the bile.

3. A consideration of the difference in concentration between liver bile and gall-bladder bile still further supports the view that cholesterol is specially selected for absorption. The bile in the cystic duct is very much more concentrated than that in the hepatic

duct, but the concentration does not affect all the solids alike. According to the figures given by Starling, sodium taurocholate is concentrated 16 times, sodium glycocholate 20 times, but cholesterol only 10 times. It would appear, therefore, that in addition to the absorption of water there is also some absorption of cholesterol.

4. It is only by means of experimental methods that any certain conclusion can be reached regarding this matter. The following preliminary experiment is interesting and suggestive, but this branch of the work is still at so early a stage that it would be unjustifiable to attach to it any undue importance.

The average blood cholesterol in a series of healthy rabbits was determined and found to be 0·25 mgrm. in 1 c.c. of blood. The variation from this figure was very slight, not more than 0·02 on either side. Five rabbits were fed on 0·1 grm. cholesterol daily. At the end of four days the gall-bladders of two rabbits (Nos. 4 and 5) were removed. The feeding was continued. At the end of the ninth day the blood cholesterol of all the rabbits was estimated. The results are given in *Table III.* In the animals with a gall-bladder the average was 0·333 mgrm., in those without a gall-bladder it was 0·215 mgrm. Something must have interfered with the absorption of the cholesterol. Many possible sources of error will have to be checked, such as the effect of the anæsthetic, of the laparotomy, etc.; but for the present the most obvious factor is the absence of the gall-bladder.

Table III.—Illustrating the Effect of Cholesterol Feeding and Cholecystectomy on Blood Cholesterol in the Rabbit.

Control (average)	..	..	25	milligrams	per 100 c.c.
1. Fed cholesterol	..	..	38	,,	,, ,,
2. ,, ,,	..	..	30	,,	,, ,,
3. ,, ,,	..	..	32	,,	,, ,,
4. Cholecystectomy	..	..	21	,,	,, ,,
5. ,,	..	..	22	,,	,, ,,

The cholesterol in the blood is derived partly from the food, partly from the bile. The work of Dorée and his associates has shown that the cholesterol in the fæces accounts for that in the food, so that the cholesterol in the bile must be absorbed. We have seen that the architecture of the gall-bladder is beautifully designed for purposes of absorption. We have seen that the gall-bladder is capable of absorbing solids as well as water. We have seen also that cholesterol is deposited in the wall of the gall-bladder in pathological conditions. The absorption of cholesterol is evidently interfered with in some way in animals from which the gall-bladder has been removed. It is suggested that the main avenue of this absorption of bile cholesterol may be the gall-bladder, and that possibly this may constitute an important function of the gall-bladder.

In these days when the gall-bladder is regarded with such dark suspicion, and is offered up, an innocent victim, on many a surgical altar, it may be well to recall that possibly after all this much condemned organ may serve some useful purpose in the animal economy.

SUMMARY.

1. A study of the gall-bladder with the binocular dissecting microscope reveals a new view of the anatomy of the organ, and throws suggestive light on the question of its function.

2. That function is undoubtedly one of absorption, and it is possible that one of the chief substances absorbed is the cholesterol of the bile.

3. The formation of deposits of cholesterol ester in the mucosa of the gall-bladder is an important feature in many cases of early cholecystitis.

4. These deposits occur both in the surface epithelium, in the connective-tissue stroma, and possibly in the lymphatics.

5. In some cases at least the first step in the development of gall-stones may consist in this formation of cholesterol deposits.

6. A new microchemical test for cholesterol in the tissues is described.

7. The normal gall-bladder of the dog contains a peculiar lipoid material in large amount. That of the cat contains a much smaller amount of the same material. In none of the other animals examined was it found.

In conclusion, I wish to express my indebtedness to those who have made this research possible—to the surgeons of the Winnipeg General Hospital for willing assistance in studying the clinical side of the subject, to Professor A. T. Cameron of the Department of Biochemistry of the University of Manitoba for much invaluable help with the chemical work: and, amongst other helpers, to Miss Olive Lightcap and Miss M. van Romburgh for their technical assistance.

REFERENCES.

[1] W. C. MacCarty and J. R. Corkery, "Early Lesions in the Gall-bladder", *Amer. Jour. Med. Sci.*, 1920, clix, 646.
[2] E. C. Rosenow, "The Etiology of Cholecystitis and its Production by the Intravenous Injection of Bacteria", *Jour. of Infect. Dis.*, 1916, xix, 527.
[3] A. Chauffard, *La Lithiase Biliaire*, Paris, 1922.
[4] K. Dewey, "Experimental Hypercholesterolemia", *Arch. Internal Med.*, 1916, xvii, 757.
[5] N. Aoyama, "Zur Frage der Cholelithiasis", *Beitr. z. path. Anat. u. z. allgem. Path.*, 1913, lvii, 169.
[6] P. D. McMaster, "Do Species Lacking a Gall-bladder possess its Functional Equivalent?" *Jour. Exp. Med.*, 1922, xxxv, 127.
[7] Peyton Rous and P. D. McMaster, "The Concentrating Activity of the Gall-bladder", *Jour. of Exper. Med.*, 1921, xxxiv, 47.
[8] W. B. Harer, E. H. Hargis, and V. C. Van Meter, "Studies of the Function of the Gall-bladder", *Surg. Gynecol. and Obst.*, 1922, xxxiv, 307.
[9] Dorée, Ellis, Fraser, Gardner, etc., "The Origin and Destiny of Cholesterol in the Animal Organism", *Proc. Roy. Soc. London*, 1908 to 1922.
[10] A. Grigaut, *Le Cycle de la Cholestérinémie*, Paris, 1913.

X-RAY PRINTS: A SUGGESTION.

By A. P. BERTWISTLE, Leeds.

It had always struck me that much of the value of *x*-ray prints in text-books was lost owing to absence of contour of the soft parts. I have accordingly tried to define the outline of these parts in such a way as to render the pictures more real.

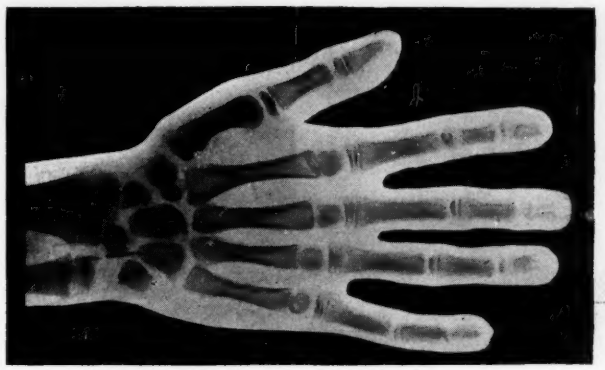


Fig. 284.

I began by outlining the edges of the parts with a paste of bismuth and paraffin. This was unsatisfactory, owing to the difficulty in marking the exact margin.

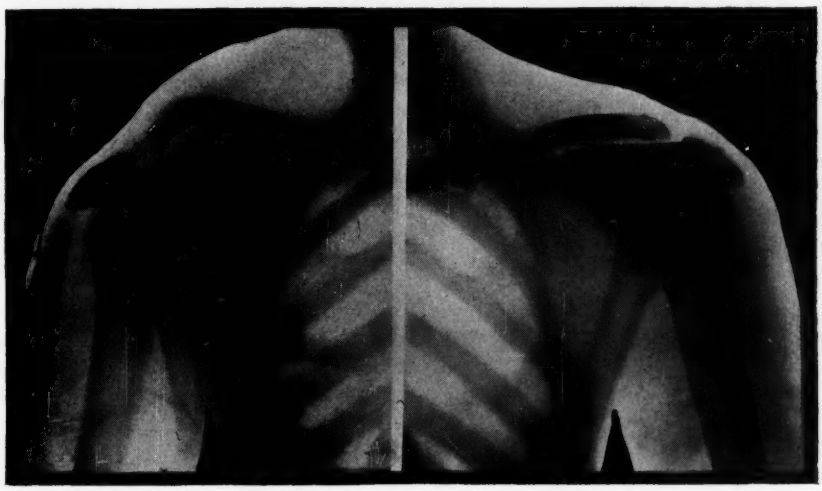


Fig. 285.

I then found that, whilst skin shows quite clearly on the negative, it does not do so on the print, though occasionally the apparent soft parts are represented by structures

deep to the deep fascia. I am given to understand this is due to the printing being done solely for bone definition. I accordingly took a series of negatives, and with a point outlined the skin. The background was subsequently filled in with Indian ink, giving the effects reproduced in the accompanying prints.

FIG. 286.

FIG. 287.

I would suggest that text-book illustrations would have a greater value if done by a similar method, which should be equally valuable for orthopædic work.

The illustrations shown (*Figs.* 284–287) are used, together with other similar ones, in the casualty reception room for instructional purposes.

VISITS TO SURGICAL CLINICS AT HOME AND ABROAD.

THE MAYO AND CRILE CLINICS: WITH SPECIAL REFERENCE TO THYROID SURGERY.

By W. H. BOWEN, Cambridge.

Round the great lakes of America thyroid disease of all sorts is endemic, and the abundance of clinical material with its pathological harvest makes the study of thyroid disease intensive and authoritative. The present paper is based on the work seen at Dr. Crile's clinic at Cleveland and the Mayo clinic at Rochester, and upon the opportunities given for discussing cases and points, courtesies so freely extended to the visitor, and which helped to enhance the value of a visit to these celebrated clinics. In the Mayo clinic I heard Dr. Boothby and Dr. Plummer lecture on thyroid disease, and was shown over the Basal Metabolism Department by the former, every facility being afforded for observation, coupled with invaluable verbal explanations. I also heard much discussion on the differential diagnosis between adenoma thyroid with hyperthyroidism, and exophthalmic goitre, a subject which the Mayo clinic has put on a firm basis by means of its wide experience and careful analysis of its cases. There is a certain friendly rivalry between the Cleveland and Rochester clinics which is of some advantage to the visitor, since the fact that he has been to the one affords ample opportunity of discussion in the other. Both these clinics are controlled by men of great skill and big outlooks, so that discussion cannot but broaden the view and enlighten the mind; and criticism in either school calls forth the very best in the way of clinical or experimental proof which a finely-equipped centre can produce. This provides a very intensive study for the student who seeks knowledge, and it is from such opportunities and without any reference to book work that I write this paper. As a matter of fact, I carefully avoided reading any American literature on the subject of thyroid disease until this paper was finished. On the other hand, I have studied British literature of the last ten years in order to gain some idea of the opinions of our leading authorities on the subject of thyroid surgery especially, and to get some impression as to the comparative standard of achievement.

One ought not to overlook a great advantage which American surgery possesses in the centralized clinic system, which tends to the free communication and interchange of opinions between the departments, especially between the pathologists, internists, and surgeons. They all have their rooms, and do their work, in the same central building—the clinic building; when a problem is hot in their minds they have but to go a few steps and they can discuss it with the colleague whose opinion is most valuable and who can supply the special knowledge required, either to clear up the doubt or to suggest those lines of inquiry most likely to prove beneficial. This is real team-working, and is probably one of the greatest assets of the American clinic system, for it has reached a level of organization which is, I think, unknown in this country. I shall have more to say on this matter when writing on Crile's surgical work on goitre—the finest demonstration of the perfection of a team system which I have ever witnessed, or, I believe, am ever likely to witness.

The main interest of this paper may be epitomized as follows: first will be given the Mayo clinic classification of goitres; secondly some reference to the Basal Metabolism Department of the same clinic; thirdly the mode of operating, with special reference to Dr. Crile's clinic; and finally, a few remarks on thyroxin.

The Mayo clinic classification of thyroid disease given by Dr. Boothby is as follows:—

1. Colloidal diffuse enlargement, which is identical with what, in this country, we call simple parenchymatous enlargement.
2. Adenoma (*a*) without hyperthyroidism, (*b*) with hyperthyroidism.
3. True exophthalmic goitre.
4. Thyroiditis, simple and tuberculous.
5. Malignant thyroid.

This classification is a good working basis for the purpose of this paper, which in part aims at emphasizing the way in which differential diagnosis has been forwarded in America. The Mayo clinic attaches the greatest importance to the differential diagnosis between adenoma thyroid with hyperthyroidism, and exophthalmic goitre. Interest centres round this problem, as it always will do around differential diagnosis, especially when the difference approaches some degree of refinement of diagnosis, and when there is clash of Olympic opinion; for this is the bone of contention between Crile's clinic and the Mayo clinic.

Before going any further, let me briefly get rid of headings 1, 4, and 5. Colloidal diffuse (parenchymatous) goitre may be dismissed with the brief reminder, well known to all, that operation is only required for æsthetic or mechanical reasons. When associated with nervous symptoms, however, Dr. Plummer contends that it may lead clinicians astray. This will be referred to later. Thyroiditis may be dismissed as being devoid of special interest, on account of its rarity and its special clinical characters. Malignant thyroid again has special characters and features of its own which put it in a grouping by itself and on the whole render its diagnosis one of no great difficulty.

Before leaving the subject of classification, let me say that the Mayo clinic realizes that a classification is but an effort to produce order out of confusion and provide some sort of basis for discussion, and that it is not final and unchangeable. Dr. Boothby told me, after giving this classification, that it was an interesting fact that in the last three years, among some two thousand goitre cases, they had four cases of diffuse colloidal enlargement of the thyroid with all the symptoms of exophthalmic goitre, and which they called exophthalmic goitre. Also, occasionally a case of adenoma thyroid became a definite case of exophthalmic goitre. They gave no explanation of these anomalies, but stated them as facts which must be accepted, however inexplicable they may appear at present.

The Mayo clinic contends that there is a wide difference between adenoma thyroid with hyperthyroidism and exophthalmic goitre; that the outlook in the two classes of case is widely different both in operative risk and curative result. Furthermore it contends that others have confused one type of case with the other, have grouped them all together under the heading of exophthalmic goitre, with a resultant low mortality from operation which would not have been achieved had the differential diagnosis been more carefully considered.

To those outside the controversy this endeavour to differentiate between two conditions clinically very similar, and both apparently requiring the same treatment, may appear as a refinement in diagnosis which is uncalled for; but longer and more careful consideration of all the factors involved, and especially the difference in operation risks, will, I believe, decidedly alter any opinion based on a superficial survey of the subject, and I venture to think it is well worth while to go over the points in differential diagnosis which the Mayo clinic emphasizes.

Dr. Boothby says that adenoma thyroid with hyperthyroidism and exophthalmic goitre are two diseases as separate as typhus and typhoid fevers. He considers adenoma thyroid with hyperthyroidism as the normal condition plus excess of thyroxin; but in exophthalmic goitre there is something more than excess of thyroxin. At the present

time he is not prepared to say wherein this difference lies, but mere speculation might suggest that in exophthalmic goitre there is some alteration in the thyroxin molecule.

The points in differential diagnosis which the Mayo clinic emphasizes in separating adenoma with hyperthyroidism from exophthalmic goitre may be roughly classified under four headings: (1) *History*; (2) *Physical signs*; (3) *Symptoms*; and (4) *Difference in metabolic rate.*

1. An important point in the history of the case is the length of time the disease has existed. The time which a case of exophthalmic goitre takes to develop is on an average eight months, whereas in a case of adenoma with hyperthyroidism, the signs and symptoms take years to develop, being preceded by a stage of adenoma without hyperthyroidism, for the one usually merges into the other. Thus adenomata begin somewhere about the age of 20 years and exist for about 15 to 20 years before taking on toxic characters, the average over a number of cases being 17·7 years. It will be gathered from this that the onset of signs and symptoms is much more clear and definite in exophthalmic goitre than in adenoma with hyperthyroidism.

2. The physical signs calling for comment are the enlargement of the gland and the exophthalmos. As would be expected, the adenomatous gland is asymmetrical as compared with the true exophthalmic goitre; but also it is noted that the very large glands are the adenomatous ones. I am not prepared to comment upon the statements made to me, but would here remark that this apparent differentiation between the two types is of course relative, and, to those who are used to diagnosing tumours, distinctions which may appear obvious on paper sometimes provide great difficulties in practice.

Exophthalmos with adenoma is uncommon and may even be said to be rare, and when present is but slight compared with the staring eye seen in exophthalmic goitre. On the other hand, exophthalmos was present in 60 to 80 per cent of cases of exophthalmic goitre.

3. Under symptoms the following are the main points emphasized: Adenomatous cases do not get gastro-intestinal crises, which are peculiar to true exophthalmic goitre, as also are thrills and bruits; the nervousness of exophthalmic goitre and that of hyperthyroidism are two very different things which experience soon differentiates; the appetite in exophthalmic goitre is large (unless there are gastric complications), whilst the weight is stationary or falling, as a consideration of the metabolic changes would lead one to expect.

4. The basal metabolism is never as high in adenoma with hyperthyroidism as in exophthalmic goitre.

Before giving some account of the method of estimating the metabolic rate and discussing its diagnostic and prognostic significance, I would like to refer to a lecture I heard given by Dr. Plummer at the Mayo clinic, in which, leaving aside the differential diagnosis between adenoma thyroid with hyperthyroidism and exophthalmic goitre, in the elucidation of which he has played so great a part, he concentrated on an entirely different subject, namely, the differential diagnosis between the colloidal diffuse goitre (simple parenchymatous) with psychoneurotic symptoms, and exophthalmic goitre. It is a less important group of cases than the adenomata, as one would expect, and I cannot say whether it may not have been exaggerated by the war. I remember Dr. Boothby mentioning this differentiation, but evidently as of comparatively small importance. Looking back, I am inclined to think that this is one of the refinements of diagnosis which are the outcome of the searching investigation and the complete report which the clinic writes on every case.

In distinguishing between these two groups of cases Dr. Plummer's chief points were :—

a. The pulse: If the patient were only nervous he would be able to tell the physician that whereas his nervousness under observation makes his heart beat rapidly, yet there are times when he knows that it is slow or relatively slow.

b. Cases of exophthalmic goitre have weakness of the quadriceps muscle noticeable when they are asked to step up. The value of this diagnostic point may be demonstrated

in this way. The exophthalmic goitre is not lacking in self-confidence, whereas usually the psychoneurotic is. If the exophthalmic case is asked to step up on to some high stool he will cheerfully acquiesce and fail to fulfil his intention, whereas the psychoneurotic can only with difficulty be persuaded to make the attempt, but steps up without the slightest trouble.

c. There is increased appetite in the exophthalmic case, as previously mentioned.

d. Exophthalmic goitres are relatively intolerant of heat. The metabolic rate and increased intake of food show they are living at an excessive rate, with dilated surface vessels (flushing and sweating) as part of the body activity. This all means that they are burning to excess with the subjective sensation of heat.

e. The metabolic rate is increased in exophthalmic goitre, as mentioned in (*d*).

In summing up his lecture, Dr. Plummer said that the three main points in differential diagnosis to which the clinic attached importance were: (1) Increased appetite; (2) Intolerance of heat; (3) Increased metabolic rate: all of which pointed to exophthalmic goitre. He stated that they had found no trouble in the differential diagnosis between exophthalmic goitre and early tubercle.

Basal metabolism, or the basal metabolic rate, is the method of estimating the metabolic changes occurring in the body during a certain period of time. It may be said to be the expression of the cellular activity of the body. At the Mayo clinic the estimations are carried out on a very large scale. They attach importance to the results, but are very careful not to attempt to influence the surgeon unduly in deciding on his mode of treatment or the prognosis. Dr. Boothby, who is in charge of the department, with the title of Chief of the Department of Clinical Metabolism in the Division of Medicine, compares the records obtained with those of a temperature chart in its bearing on the diagnosis and prognosis of a fever, which anyone will agree is a very modest position to take up, although entirely in keeping with his scientific attitude. He points out that he advises neither the line of treatment nor even the type of operation. He supplies certain data which, forming part of a whole, play a part in the making of a diagnosis and deciding the line of treatment.

The department is in a wing of one of the top floors of the Colonial Hospital. It comprises dressing-rooms for the patients and the rooms where the clinical investigations are carried out on one side of a corridor, and on the other a large laboratory, staffed by girls, where the gas analyses are made under supervision, and, adjoining this, private laboratories for Dr. Boothby and his colleague, Miss Sandiford. The division given up to the clinical investigation of patients consists of two rooms alongside each other with a small ante-room common to both, where the expired air is collected into special gas chambers. The patient on arrival lies on a couch for about twenty minutes so as to enable him to be quiet and comfortable and free of undue physical or mental stimuli. A respirator is then put over his mouth and nose, with a mask so constructed that there shall be no escape of air at the side. This respirator has attached to it two thick rubber tubes, one connected with the outside air, the other going to the collecting chamber mentioned above, to do which it passes through the wall separating this room from the ante-chamber. The respirator being applied, the collecting of the gases is begun at a fixed moment timed by three observers and activated by the turning of a tap.

The analyses of the oxygen and carbon dioxide in the expired air are carried out with the Haldane gas analysis apparatus, and from this the rate of tissue change is estimated. It appears that the estimation of the basal metabolic rate is essentially of value in thyroid disease, and its value as a clinical adjunct is practically limited to the study of this disease. It is the measure of the cell activity, and its great value is in deciding whether a patient has exophthalmic goitre, and the rate of tissue waste which is going on. Its bearing may be summed up in the words of Dr. Boothby that in exophthalmic goitre the weight and the basic metabolism are the two important factors. If the rate is over 50 it means a severe condition; but with that statement came the reiteration of the warning that the Department of Clinical Metabolism does not decide what can or should be done in the way of operation.

At the Mayo clinic the Department of Basal Metabolism was opened in March, 1917, and by the end of that year 1143 estimations had been made. They have been carried out on much the same scale ever since, so that it will be realized that it is no longer an experimental inquiry. On the other hand, Dr. Crile is sceptical as to its value, and although he has it carried out in his clinic it is entirely subsidiary to the clinical examination. At Cleveland it may be said to be still on trial, the precariousness of its reputation resting on the possible margin of error.

Before considering operative treatment, let me refer briefly to other modes of treating the diseases of the thyroid. It will be realized that the problem is essentially the treatment of exophthalmic goitre, for the other forms of enlargement sink into insignificance compared with the risks run in operating on the true exophthalmic goitre case.

X rays are abandoned. It has not been proved that they affect the course of the disease materially. Iodine is not advised in cases of adenoma, save in small doses and over a short period of time. Dr. Marine says that its free use over an extended period is liable to set up hyperthyroidism. I heard Dr. Charles Mayo say in the operating theatre that thyroid extract can be tried in young people, but in older patients it caused degenerative changes and was to be avoided. There is no other drug treatment save what is symptomatic, such as digitalis for cardiac embarrassments.

The treatment in Crile's clinic and the Mayo clinic of all forms of goitre except the colloidal diffuse (parenchymatous) is operative. Preferably a thyroidectomy is done. If this is inadvisable on clinical grounds, ligation of the superior thyroid arteries is performed. Both sides may be operated on at once, or after an interval of a few days. Dr. Crile allows an interval of three days to elapse between the tying of the two vessels. After the ligation of the superior thyroid arteries the patient is sent home for two or three months : she then returns for further examination, and usually a thyroidectomy is done. The beneficial result of ligation, which is unquestionable, is differently explained by the two clinics. In Crile's clinic it is said to be due to the tying in of the nerves with the vessels, whilst the Mayo clinic insists that it is entirely a matter of partially cutting off the blood-supply. In neither of these clinics did I see any attempt to ligate the inferior thyroid vessels. The injection of the gland with hot water is still occasionally done in the Mayo clinic, but Boothby said its chief value was in seeing how the patient reacted to any form of surgical interference.

In the Mayo clinic the goitre patient has no differentiation from others. The morning work usually begins with thyroid cases, but they are brought into an empty theatre and put straight on the operating table, for anæsthetic rooms are unknown. Ether by the open method is usually given, and when the anæsthesia is induced the surgeon and his assistants and visitors enter the theatre and the operation begins. In Crile's clinic, again, there are no anæsthetic rooms. Usually the anæsthetic is entirely a local one, ½ per cent novocain supplemented by gas and oxygen if necessary, and occasionally just a little ether. At one time Dr. Crile adopted the method, which is now well known, of taking the patients up to the theatre and bringing them back again without operating, in order to see how they reacted and to get them used to the novelty of going to an operating theatre. This he has abandoned, but now often operates in the patient's room, the patient lying in bed. He says they have proved that the carrying of the patient to the theatre has a definite risk of its own. This of course refers to cases of exophthalmic goitre of the more severe sort. Another preliminary measure employed is to try the patient with gas and oxygen beforehand : this is scarcely more than picking up an acquaintanceship with the anæsthetist and the gas and oxygen apparatus. Dr. Crile says that in cases of exophthalmic goitre they have reduced the shock of operation to the point where the admission of the patient to hospital is a bigger shock than the operation itself.

Although thyroidectomy is the treatment of exophthalmic goitre, this does not mean that the condition is looked upon as primarily a disease of the thyroid gland. The view is that the thyroid element in the disease is comparable to a link in a chain. It is, as far as is known at present, the only tangible link, and, from the point of view of treatment, the only one open to direct attack. Hence thyroidectomy is openly recognized, not as a

specific treatment, but as a line of attack which, in the absence of any other form of treatment, justifies itself on theoretical grounds. It is now generally recognized that this theoretic principle is consolidated by the surgical results.

The operation of thyroidectomy in America is much more complete than any I have seen in this country or any I have seen described in British literature. The operation of resection described by Berry is the only modification of the hemithyroidectomy which is in any way comparable to the operation seen in America. Thyroidectomy is not an operation limited to Cleveland and Rochester, for I saw it carried out at Baltimore and Chicago. It consists in the removal of both lobes and the isthmus, save for a posterior portion of each lateral lobe equivalent to about one-quarter to one-sixth of the total volume of a normal thyroid gland. It is not a hemithyroidectomy, but a final operation, and it shows no hesitancy in cutting across the gland substance in order to leave the extreme posterior part of each lateral lobe behind.

The advantages claimed for the operation are a removal of a maximal amount of diseased gland with a maximal benefit, the retention of sufficient glandular tissue to prevent myxœdema, and—by leaving the posterior surfaces of the lateral lobes—the risk of damage to the recurrent laryngeal nerves is reduced to a minimum, the parathyroids are not removed, and the lateral surfaces of the trachea are untouched. The incision and method of approaching the gland do not call for comment. That it is a very severe operation will be recognized by anyone who has operated much in this line of work. In the hands of the expert it has the appearance of simplicity of technique which is so liable to be the undoing of the novice. I saw many operations in the Mayo clinic and in Crile's clinic, both ligations and thyroidectomies, and never saw any trouble. I was seeing expert master surgeons operate, and skill and speed were combined.

Gentleness of manipulation as a cardinal rule of operating is coming into general recognition ; but in a condition like exophthalmic goitre it ought to be looked upon in the same light as aseptic technique. I have never seen delicacy of touch, gentleness of handling, and speed of operating, carried to so high an artistic pitch as is seen in Dr. Crile's work. The scheduled time for a thyroidectomy at the Lakeside Hospital is fifteen minutes, and it is done in the time. Not only done, but almost bloodlessly ; and so methodically as to give the impression of simplicity even where a goitre of large size and great vascularity is concerned ; and whilst speed is recognizable—for all the operator's movements are the quick, active movements of a virile intelligence—there is no hurry and no sign of strain or anxiety anywhere in the theatre. This is due not only to the skill of a master surgeon, but to the foresight and capacity for organization without which speed and accuracy in operating would not suffice.

Team work, an expression which has become so common on men's lips in this country in reference to certain crude efforts at organization, is seen carried out to plan in the greater American clinics. In both the Mayo and Crile clinics, when a surgeon comes to operate he always operates in the same theatre or group of theatres, and with the same assistants and accessories. Surgical skill combined with an almost perfect team system is what enables Dr. Crile to complete a thyroidectomy in fifteen minutes, not in a special show case, but in a series of cases. Is the time likely to be improved upon? I doubt it. Dr. Crile at the Lakeside Hospital at Cleveland has three theatres, five assistants, and a highly-trained set of theatre nurses. His patients are operated on in the same theatre, with the same instruments, the same assistants, the same nurses, the same gowns, towels, swabs, and gloves, whether they come from the almshouse round the corner or the home of the city magnate. In the best American medical centres the nursing home is part of the hospital. The splendid hospitals of the Mayo clinic are the ultimate evolution of the crude institution called a nursing home in this country. At the Lakeside Hospital, as at the Boston hospitals and those I saw in other cities, the nursing home is an annexe to the hospital. It is a part of the hospital built with single rooms instead of wards ; but beyond this the gulf between the hospital and nursing home does not extend. That we shall have to follow the American system in this country I have no doubt at all, and the surgeon of fifty years

hence will no doubt smile sympathetically when he reads of what his predecessors put up with in the early post-Listerian era. The change will have to come gradually, and I think will best be realized by building an annexe in the form of a separate block to an existing hospital, using the hospital theatres, pathological departments, and entire staff alike for the charity and paying patients, or, in the case of large centres, by building entirely separate paying hospitals, as has been done already in Birmingham and other large towns.

Team work is seen to perfection during a thyroidectomy at Cleveland. I have represented in the accompanying figure (*Fig.* 288) the positions of the various members of the surgical team or service. The nurse anæsthetist is ready at the patient's head with a gas oxygen apparatus; but this is only given at the surgeon's orders. Infiltration anæsthesia with ½ per cent novocain is the usual anæsthetic. If this local anæsthetic only is used the anæsthetist sits close to the patient's head and talks to her all the time very quietly and soothingly, or firmly, as may be necessary. Dr. Crile stands at the patient's left side. He makes the skin incision with the left hand—being ambidextrous—but after this he does most of the work with the right hand. Practically he cuts all the time. Serious traction is never seen. Occasionally he may put a finger in the wound to feel the limit of the growth and to separate gently where such can be done easily and expeditiously, but never otherwise. He has no respect for muscles if they obscure a view of the operation area. Should the thyroid go under the sternomastoid, he divides the muscle in order to expose fully the limits of the gland. One never sees a retractor used. He but rarely picks up a Spencer Wells, all the picking up of vessels being done by his chief assistant, who stands opposite to him. The second assistant, who stands to the left side of the head of the table, constantly, and yet without acting as an obstructionist, mops the wound dry. There is a third assistant who stands at the left of Dr. Crile near to the bottom of the table, and his duty is to supply the chief assistant with Spencer Wells' artery forceps. He has literally dozens of them, for the whole wound seems hidden by them when the operation is completed. The almost automatic character of this thoroughly organized assistance is seen in the way the first assistant puts his hand out towards the third without looking, and the Spencer Wells is not only put into his hand, but in such a position that it can be used at once. Whether as an exhibition of surgical skill or team work, it is a sight worth going a long way to behold. I never saw a hitch, and I think I saw fully a dozen goitre operations. I never saw Dr. Crile mop the wound, and I have seen a whole operation done without his touching a Spencer Wells. He just cuts and cuts; and when he has finished the thyroid is separated out, isthmus and both lobes—save for the small posterior shaving of the lateral lobes to which reference has already been made. The vessels are tied off with catgut, chiefly by transfixion. In all the operations for toxic goitres the wound is left open and packed, being sewn up in from twenty-four to forty-eight hours. There are three reasons given for this, viz.: (1) That the aseptic exudate from the raw thyroid surface is toxic; (2) There is less pain; and (3) That it shortens the operation

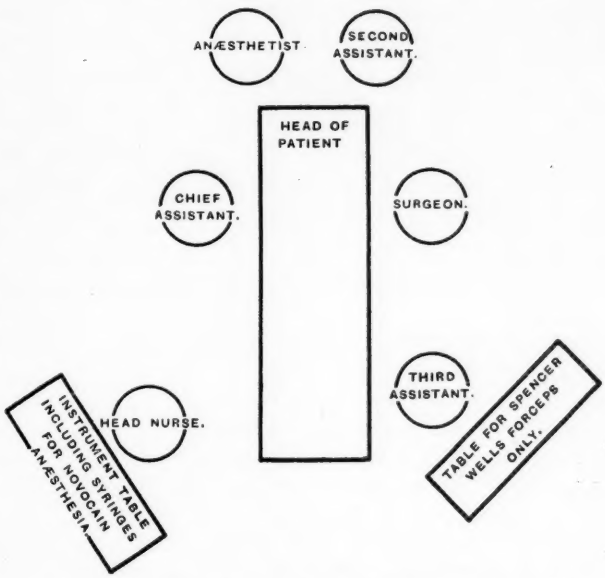


FIG. 288.—Diagram to show the position of the operating staff and the tables.

time. Going round one morning with Dr. Crile, I saw a patient thirty-six hours after operation, and twelve hours after the wound had been sewn up ; she was comatose. The stitches were promptly taken out and the wound packed open. I saw her again next morning, and though still looking ill, she was quite conscious and could talk.

I was told that in the first six months of the year (1921) there were performed 2443 major operations of all sorts in Dr. Crile's clinic, with a total mortality of 2 per cent. This included all emergencies and bad cases. The mortality of all goitre operations is 1⅓ per cent.

The little I have to say about thyroxin I learned from Dr. Boothby. It is the active principle of the thyroid gland, first separated out by Dr. Kendal of the Mayo clinic. The amount found in the normal gland is about 14 milligrammes. It wears away at the rate of about half a milligramme a day, but to replace this loss it is necessary to give one to one and a half milligrammes a day. When injected it takes twelve hours to act at all, and does not reach a maximal physiological effect for five days. Knowing this, the Mayo clinic is opposed to the ordinary method of starting with small doses of thyroid and working up to a large one. It rather advises an opposite procedure.

In conclusion, it should be remembered that this paper is the result of first-hand experience and is entirely devoid of any result of book-study. Whatever virtues it possesses, I very willingly ascribe to those to whom such an acknowledgment is due : to the workers of the Mayo clinic, and especially to Dr. Boothby, who gave time and trouble to the stranger within the gates ; and to Dr. Crile, at whose clinic I saw so much of what modern surgery can be.

A METHOD OF LIGATURING THE FIRST STAGE OF THE LEFT SUBCLAVIAN ARTERY FROM BEHIND.

By ARNOLD K. HENRY, Dublin.

While engaged recently in investigating another problem of the upper thorax upon the cadaver,* I came almost by accident on a relatively simple method of ligaturing the first stage of the left subclavian artery. After demonstrating this method upon several occasions in the School of Anatomy of the Royal College of Surgeons in Ireland, I found that another posterior approach had been used by Sherrill in 1910 and published by him in 1911.[1] Only 21 cases of ligature of the left subclavian in its first stage are on record, and 7 of these were performed since Sherrill's operation, which is the solitary instance of a posterior approach to this forbidding artery.†

The anterior approach to the left subclavian is notoriously difficult; a formidable array of nerves and vessels screen the artery. Through these but narrow access is gained, even after resection of the inner end of the clavicle, the first rib cartilage, and part of the manubrium. In actual practice, too, the upward bulge of an aneurysm into the neck will not simplify the surgeon's task. The posterior route has the merit of simplicity, and surgery advances through simplification to security. I thus venture to describe in detail the route upon which I chanced.

The transverse process of the second dorsal vertebra, and three inches of the second rib, measured from its head, were removed from the left chest of a hunchbacked cadaver after carefully separating the rib from the parietal pleura. In effecting this separation the pleural dome was slightly depressed, and the first stage of the left subclavian artery appeared in the field. Further separation and depression of the pleura exposed the artery from its point of origin at the aortic arch to the first rib, and definition of all its branches except the thyro-cervical trunk was easy. These structures were rendered surprisingly superficial by the kyphotic deformity of the back. Examination of normal subjects showed that in them the left subclavian artery and its branches are further from the dorsal surface of the trunk. The first stage of the artery, however, is just as easily tied in spite of the depth at which it lies, for once the lung and pleura have been depressed, the artery, except for a delicate sheath, lies naked in the thoracic cavity, and is immediately accessible. There is no barrier of vein or nerve; the vessel is directly under the finger. With a suitable needle it is easy to pass a ligature round the artery, and at my request this was done by students who had never previously tied any vessel in the body. Before describing the steps of the operation, certain anatomical points must be dealt with.

ANATOMICAL CONSIDERATIONS.

The Muscular Planes.—The part of the second left rib which is removed lies between the scapula and the vertebral spines: it is concealed by muscles which anchor the scapula to the vertebræ. The trapezius is spread over the rhomboids, which cover the upper serratus posterior. Division of these muscles allows the surgeon to widen the space

---

* "Posterior Route for Excision of the Cervico-dorsal Ganglion of the Sympathetic." (*Section of Surgery, Royal Academy of Medicine in Ireland*, April 28, 1922.)

† Sherrill raised a flap of skin and muscle and removed about three inches of the 2nd, 3rd, and 4th ribs. After pushing aside the pleura, the artery was exposed at the level of the 4th dorsal vertebra as it left the aorta.

between the scapula and the spine, and it is essential that the transverse width of the wound should be as great as possible. Deep to the muscles of the shoulder girdle, the splenius spreads upwards from the dorsal spines; and lateral to the splenius are the cervical extensions of the erector spinæ (*Fig.* 289).

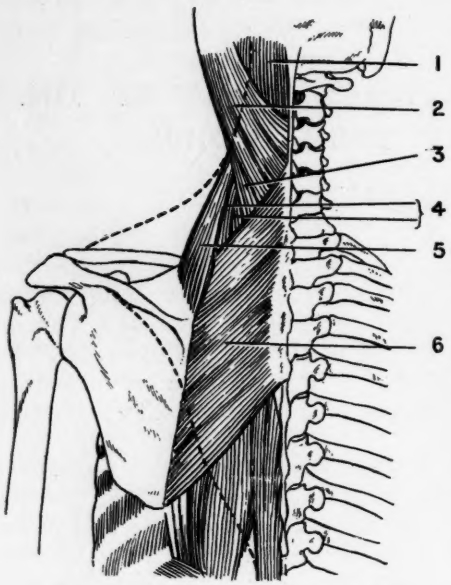


FIG. 289.—Showing the muscles that lie deep to the trapezius, which is indicated by the dotted line. (1) Complexus. (2) Splenius capitis. (3) Splenius cervicis. (4) Cervical extensions of erector spinæ. (5) Levator scapulæ. (6) Rhomboids.

The Second Rib.—The second rib must be accurately identified. It is not difficult to mistake it for the first, and thus in error to remove the third rib. The second rib and transverse process viewed from behind lie dorsal to the first, and the body of the first rib runs almost directly forwards from the costo-transverse articulation; it is difficult to palpate. When, however, the trapezius and the other muscles passing to the scapula have been divided and retracted, the first rib can be felt by hooking the finger deeply down along the neck.

The first dorsal transverse process is a good landmark (*Fig.* 290): it lies at the level of the 7th cervical spine, two finger-breadths from the middle line. It is the first transverse process to project beyond the edge of the splenius. Here its tip is felt but is not seen, being covered by two cervical extensions of the erector spinæ (the iliocostalis cervicis and the longissimus cervicis). Reckoning from this landmark, the surgeon finds the second transverse process and the second rib.*

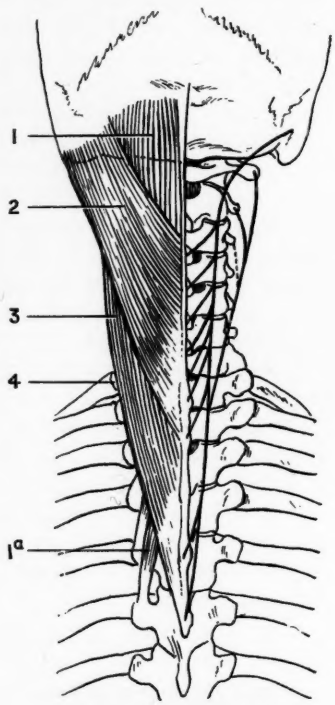


FIG. 290.—The 1st dorsal transverse process is the first which projects beyond the edge of the splenius. It forms a deep landmark for identifying the 2nd rib. (1) Complexus. (2) Splenius capitis. (3) Splenius cervicis. (4) 1st dorsal transverse process. (1a) Complexus.

The Left Subclavian Artery.—The anterior relations of this artery in its first stage make an impressive list. Deep to the muscular planes consisting of the sternomastoid, sternohyoid, and sternothyroid, lie the left innominate, internal jugular, and vertebral veins, succeeded by the vagus and phrenic nerves, the carotid artery, and branches of the cervical sympathetic. In the posterior approach, however, when the pleural dome has been depressed, only one minute structure intervenes between the surgeon and the artery, the ansa subclavia of Vieussens. This tough but slender loop crosses the back of the subclavian as the vessel arches after giving off its vertebral branch (*Fig.* 291). The depth of the proximal part of the artery from the dorsal surface is about three inches; that is to say, if the index finger could be thrust through the skin it would just touch the artery. By making a large flap as described below, the thickness of the skin and subcutaneous tissue is eliminated from the field, and suitable division of the muscles to the shoulder girdle

* For additional security the second rib should be localized by radiography before operation, and the radiologist should be asked to examine the thoracic inlet for accessory cervical or rudimentary thoracic ribs, which might confuse the surgeon approaching them from behind.

allows the surgeon to work *from the plane of the thoracic wall.* The 'working depth' of the artery is thus reduced to two inches, which is the actual depth of the artery from the upper border of the manubrium in front. The 'working depth', therefore, is the same whether the approach is from the front or back.

The Left Vagus.—The presence of the left vagus need not be feared. The relations of the nerve depicted in most text-books of anatomy are those which it assumes after it has been freed by dissection. It then falls away from the common carotid, and lies close in front of the first stage of the subclavian. If this were its true position, it would be in danger when the artery was tied from behind. Actually the nerve is, as Charpy[2] states, a satellite of the common carotid, and passes downwards and inwards close along this artery, coming gradually forwards as it descends: it thus lies beside, rather than behind, the left carotid at the root of the neck, and is on a plane anterior to the left subclavian (*Fig.* 292). About a finger-breadth above the aortic arch the direction of the vagus changes abruptly; the nerve passes out, down, and back, to cross the root of the left subclavian artery, so that this part of the vagus lies between the vertical carotid and subclavian origins of the left side like the oblique stroke of the letter N (*Fig.* 293).

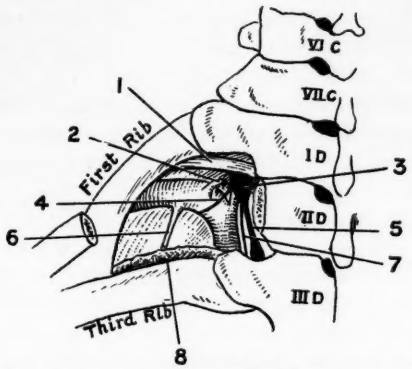


FIG. 291.—The relations of the first stage of the left subclavian artery seen from behind after removal of the 2nd dorsal transverse process and part of the 2nd rib. The œsophagus, and the thoracic duct which stripes its left side, are not shown in the figure: they are nearer the middle line. To see the origin of the subclavian artery from the aortic arch and to tie the *proximal* part of the artery the surgeon stands opposite the head of the table. (1) 1st dorsal nerve. (2) Costo-cervical trunk. (3) 1st dorsal ganglion of sympathetic concealing vertebral artery. (4) Ansa subclavia crossing subclavian artery. (5) Sympathetic cord passing to 2nd dorsal ganglion. (6) Internal mammary artery. (7) Inferior cardiac branch of sympathetic. (8) Pleural dome retracted downwards.

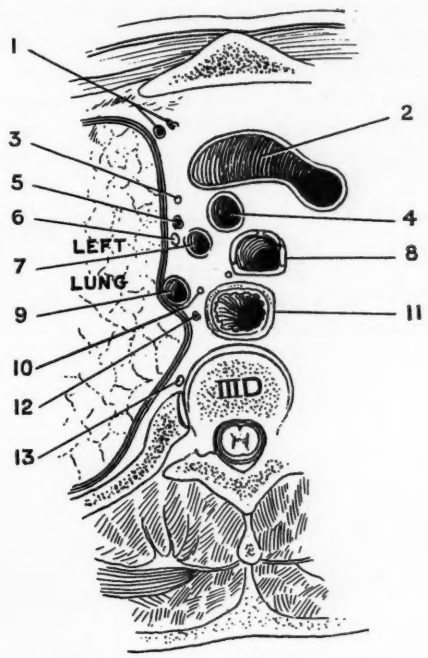


FIG. 292.—Cross-section through 3rd dorsal vertebra and upper part of manubrium, showing relations of left subclavian artery. Note that the left vagus is still a satellite of the common carotid; the thoracic duct adheres to the œsophagus and is in no danger of injury. (1) Internal mammary vessels. (2) Left innominate vein. (3) Phrenic nerve. (4) Innominate artery. (5) Left superior intercostal vein. (6) Vagus nerve. (7) Left common carotid. (8) Trachea with left recurrent laryngeal nerve. (9) Left subclavian artery. (10) Inferior cardiac branch of cervical sympathetic. (11) Œsophagus. (12) Thoracic duct. (13) Sympathetic cord lying in front of costovertebral joint between rib and vertebral body.

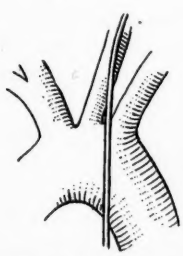


FIG. 293.—Diagram showing left vagus related to the left carotid and left subclavian arteries like the oblique stroke of the letter N. The vagus is safe from inclusion when the left subclavian artery is tied from behind.

Further, there is a barrier between the vagus and the subclavian which protects the nerve from inclusion when the artery is tied by the posterior route. This barrier consists

of a layer of areolar tissue which contains: (1) The middle and sometimes the superior cardiac branch of the cervical sympathetic; (2) Descending œsophageal and tracheal branches of the inferior thyroid artery; (3) An occasional thymic tributary of the vertebral vein. These structures not only make it difficult to expose the subclavian from in front, but obscure the origin of the vertebral artery, which tends to lie at a relatively low level on the left side.

The Left Vertebral Artery.—This vessel during development is often absorbed into the aortic arch, and seen from in front may be mistaken for the subclavian, since it then arises from the arch between the left common carotid and the subclavian trunk. This error will not be made in ligation from behind.

The Thoracic Duct and the Inferior Cardiac Nerve.—The thoracic duct will not be injured from the back; it stripes the left side of the œsophagus in the superior mediastinum, and only leaves it to pass in front of the root of the vertebral artery. In an anterior attack the duct, though not in contact with the first stage of the subclavian, may be injured as it arches outwards over the vertebral origin.

The inferior cardiac branch of the sympathetic also lies medial to the artery. With the most ordinary care it is easily avoided (*see Fig.* 291).

TECHNIQUE OF OPERATION.

A good head-light should be used, but in the cadaver I have repeatedly tied the artery without artificial illumination. The patient should lie prone, with the left shoulder clear of the table and the left upper limb hanging vertical (*Fig.* 294). Make the upper dorsal region as kyphotic as possible. This gives the space between the scapula and the vertebral column its maximal width.

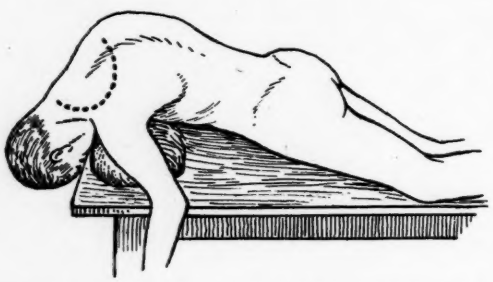


FIG. 294.—Showing skin incision and position securing maximum abduction of the scapula.

1. Find the 7th cervical spine. Mark: (*a*) A point four finger-breadths above it and one finger-breadth to the *right* of the middle line; (*b*) A similar point six finger-breadths below the 7th spine; (*c*) A point over the middle of the spine of the left scapula. Join these three points by the incision shown in *Fig.* 294, which is carried down to the sheath of the trapezius muscle. Raise the flap of skin and subcutaneous tissue thus outlined and turn it over to the *right* of the middle line.

2. With a vertical cut one finger-breadth to the left of the vertebral spines, divide the origins of (*a*) the trapezius, (*b*) the rhomboids, and (*c*) the serratus posterior superior. Do this first at the middle of the wound where the silvery tendon of the serratus indicates the depth reached. Extend this incision throughout the entire length of the wound. Retract the divided muscles outwards. The pointed caudal end of the fleshy splenius is now exposed.

3. At the level of the 7th cervical spine and two finger-breadths from the middle line, find the tip of the first left dorsal transverse process, remembering that it is the first which projects beyond the edge of the splenius. Find the second left rib.

4. Clear the transverse process of the second dorsal vertebra as far as the lamina. Clear at least three inches of the second rib. Divide the transverse process at its root and remove it. Divide the rib as far as the wound will permit from the costo-transverse articulation.

5. Raise the proximal cut end of the rib. With finger push the pleura away from its head and neck. Rotate the rib segment and divide its attachments. The sympathetic cord is now seen close to the vertebral body, lying on the pleura like a tape.

6. Very gently push the pleural dome downwards and outwards from the vertebræ.

A small strand will now be found holding the pleura to the neck of the first rib. This strand is a branch of the superior intercostal artery. Divide and tie it. The pleural dome can then be freely depressed, and the left subclavian is felt by the finger passed vertically and at a tangent to the vertebral body. *The removal of the transverse process, together with the costal neck, permits of this direct approach.* A broad malleable retractor keeps the lung and pleura out of the field. It should be polished so as to reflect light into the cavity. The artery is isolated under direct vision by blunt dissection, and its sheath is opened in the usual manner, using a long dissecting forceps. The ansa subclavia should be avoided.

7. The surgeon stands facing the head of the table. An aneurysm needle with a slot eye is passed with the *left* hand from within outwards : introduction of the right forefinger into the wound facilitates this manœuvre. The eye is threaded with a ligature, or with a guiding thread to which a definitive ligature (a tape, for example) is attached. Ample space is afforded for securing the knot.

The internal mammary and costo-cervical trunks can be tied at their origins. The vertebral artery is obscured by the cervico-dorsal ganglion of the sympathetic, but can be safely ligatured by opening the subclavian sheath close to the vertebral origin and passing an aneurysm needle round the parent trunk so that its point appears in the angle between the subclavian and the vertebral artery. The thoracic duct may thus be avoided. The thyro-cervical trunk is difficult to secure by the posterior route.

My best thanks are due to Professor E. J. Evatt, D.S.O., for the many opportunities he has given me of testing this method on the cadaver. For the figures illustrating this paper, I am indebted to the text-books of Cunningham, and of Poirier and Charpy, from which they have been modified.

SUMMARY.

An approach to the first stage of the subclavian artery is obtained by costo-transversectomy at the level of the second rib on the left side. Depression of the pleural dome leaves the artery naked from the aorta to the first rib, no structure (excepting the ansa subclavia) intervening between the operator and the vessel.

The first stage of the vessel can be ligatured in any part of its course, and its branches, except the thyro-cervical trunk, can be tied with relative ease.

REFERENCES.

[1] *Trans. Southern Surg. and Gyn. Assoc.*, vol. xxiii, quoted in *Johns Hop. Hosp. Reports* by W. S. Halsted, vol. xxi, fasc. 1.

[2] *Traité d' Anatomie*, 2nd ed., vol. ii, pt. 1, p. 426.

THE PLACE OF OPERATIONS FOR SPINAL FIXATION IN THE TREATMENT OF POTT'S DISEASE.

By G. R. GIRDLESTONE, Oxford.

In 1919 I published a paper[1] on 50 cases in which operative spinal fixation had been performed by my colleagues or myself. I have now particulars of 50 additional cases.

It is desirable that the results of the operation should be examined, and its value and place in the treatment of Pott's disease critically assessed. In the past, operation has too often been thought of as if it did in itself definitely provide a short cut to the cure of Pott's disease. Wholly extravagant claims have been made on behalf of this new means of treatment, and altogether too much reliance has been placed upon it; cases have been treated by operation without proper splintage, without open-air methods, and without adequate rest or sufficient time. This mistaken view of the scope of operative fixation has led to many failures and much disappointment. As a result the operation has not been seen in true perspective. It is highly esteemed by those who use it as "part of the conservative treatment of Pott's disease".[2]

There can be no short cuts to cure in this disease. End-results teach us that in serious bone and joint tuberculosis short cuts lead altogether in the wrong direction. In the spinal lesion the gradual processes which end in cicatrization take their inevitable time. And this lesion is only part of an invasion of the patient's body by the tubercle bacillus; he is mortally attacked; for the time being the invader is gaining ground and the victim exhausted. Every influence to restore and raise his vitality must be applied. His needs are twofold, and before treatment is complete: (1) His general health and powers of reaction must have risen superior to the destructive activities of the tubercle bacilli, in his spine, and elsewhere; (2) The spinal lesion must be healed, and sound structural stability of the damaged part re-established. Operative spinal fixation may help in the splintage of the spine during the disease, and add to its stability afterwards, but it cannot replace the established principles of treatment.

Rationale of Operations for Spinal Fixation.—The object of the various methods of operative fixation of the spine is to promote bony union between the dorsal elements of the vertebral column and so to provide permanent internal splintage of the affected part.

Apparently Albee's plan of graft fixation[3] grew out of comments that Brackett had made on the natural ossification between and round the spinous processes which occasionally occurs in the course of Pott's disease.[4] This interlaminal and interspinous ankylosis occurs very slowly, and only after extensive destruction of the bodies has led to a crowding together of the laminæ and spines. It was clearly desirable, if practicable, to promote bony union between the spines or laminæ before, rather than after, destructive lesions had taken place.

Hibbs[5] states the reasons that induced him to develop and carry out his method of operative fixation thus: "It was felt that absolute elimination (of motion) would hasten the cure and perhaps prevent deformity. The absolute elimination of movement in any joint is accomplished only when the bones entering into its formation become fused. . . . This is sometines accomplished by nature without operative aid. In the case of a vertebral joint affected by tuberculosis, however, nature is too slow".

The Statics of the Spine in Relation to Caries.—A review of the mechanical problem involved by destructive lesions of the vertebral bodies is an essential preliminary to an intelligent discussion of the value of the operations designed to promote spinal fixation.

Spinal mechanism is very complex, but in relation to caries it can be considered in a simplified form. The spine may be represented as composed of three units: (1) Anterior (somatic) column—centra and discs; (2) Lateral columns—articular and other lateral processes; (3) Dorsal processes—laminæ and spines. The bodies contain much of the spongy bone and red marrow beloved of the tubercle bacillus, whereas the lateral columns and dorsal processes are formed of comparatively hard bone, which is seldom attacked and resistant to destruction. The weight of the body is normally carried both by somatic and lateral columns.* The dorsal processes form a system of levers which are moved or held by the erector spinæ muscles; they carry no direct weight whatever, but act purely as levers working on the fulcra furnished by the lateral articulations. The movements of flexion and extension are controlled by the lateral columns, though the axis of movement does not necessarily pass through the lateral articulations.

When caries causes extensive loss of substance in the somatic column, two processes are likely to take place: (1) Telescoping; (2) Inflexion.

1. *Telescoping* is a sliding of the lateral articulations, and 'crowding together' of the dorsal processes, to correspond with the degree of somatic loss. Now this movement is limited by the shape of the lateral articulations and by imbrication of the dorsal processes. It is especially free in the lumbar region. When telescoping has reached its limits and somatic destruction still continues, another and entirely distinct process comes into play unless the posture of the spine is artificially controlled by effective splintage. This second process is—

2. *Inflexion*, i.e., a 'falling forward' of the segment of spine above the gap until the body above is once more supported. If there is not much destruction, the under surface of the centrum above the gap meets the upper surface of that below. But if there is extensive loss of bone substance, it is the anterior surface of the body above the gap that will be opposed to the upper surface of the centrum below. This extreme and strictly localized flexion (Menard's 'complete inflexion') involves a subluxation of the lateral articulations, with the result that the lowest lateral articular surface of the upper segment rests on the 'knife edge' of the upper lateral articular surface of the segment below the gap. This is a most unstable condition, and represents the so-called 'pathological fracture-dislocation' of spinal caries.

If, however, when telescoping is complete the spine is firmly maintained in the extended position, the pressure is taken entirely on the lateral columns, an actual gap in the bony continuity of the somatic column being left. Now this local extension of the spine can sometimes be maintained in recumbency by careful posturization, but it cannot be maintained by any external splintage when the patient gets up.† Usually there is gradual development of 'complete inflexion' (Menard). All that ambulatory splintage can do is to ensure the development of sufficient compensatory curves just above and below the lesion, so that the hump may be minimized and erectness of the spine as a whole may be restored.

It was hoped that the production of a synostosis of the dorsal processes, and the maintenance of approximation of these posterior levers, would achieve a permanent local extension.

What can Successful Spinal Fixation Actually Achieve?—

1. The operations of so-called 'spinal fixation' are in no sense radical; they do not aim at, or encompass, any extirpation of the diseased parts.

2. They are directed toward fixation of the dorsal units only, and should really be termed 'posterior spinal fixation'. The dorsal units do not carry weight, but consist of a series of levers connected by, and acting through, the lateral columns.

3. Successful posterior spinal fixation produces a series of bony bridges uniting and holding a succession of these levers. This artificial synostosis of the dorsal units is only

---

* Throughout this description for the sake of simplicity the spine is supposed to be erect.

† Cases of definite local bone destruction producing a gap in the somatic column are being discussed.

sufficient to prevent flexion of the segment if the lateral columns present a series of fulcra. The lateral columns then actually carry the weight, while the graft (or osteoplastic connection) maintains the approximation of the dorsal levers and stabilizes the upper and lower segments at their junction on the fulcra.

4. The union between the dorsal units is not designed to stand a cross-breaking strain. Provided the lateral columns furnish the fulcra, the tendency of the upper segment to fall forward at the site of the lesion will throw a strain consisting mainly of vertical tension on the graft (experimentally shown by Calvé and Gulland, de Quervain and Hoessly, and others).

5. Posterior spinal fixation, since it acts by leverage and stabilization and does not produce direct sustentation, is a form of splintage. It helps to protect, but cannot replace, the natural process of healing. Spinal fixation may play a useful part in the organized provision of *rest* and *time*. Successfully achieved, and in suitable cases, it aids the rest and shortens the time, but cannot replace either.

6. Spinal fixation offers a further effect in preventing deformity if it suffices to maintain local extension of the diseased segment after the patient gets up. This depends on: (*a*) The strength and stability of the lateral columns; (*b*) The protection of the new bony tissues from strain until they are strong enough to stand it without giving way. For the latter, adequate splintage, the stimulus of gradually increased function, and time are necessary.

Various Methods of Posterior Spinal Fixation.—A number of methods have been devised in order to achieve this end. The spinous processes have been wired together, but the wires gradually cut through the bone. Calot had suggested the turning up and down of periosteal flaps from the spinous processes, and Hibbs developed and extended this method, turning up and down flakes from the laminæ, and producing interspinous union by the partial section and fracture of the spinous processes.

Albee used a graft from the tibia. De Quervain, independently, and only slightly later, used a graft from the spine of the scapula (having previously applied this method in 1911 in the treatment of fracture-dislocation of the spine). These writers quote Ombredanne as having used the median border of the scapula, Toblasec as using a portion of rib. More recently Gallie and Robertson[6] in Canada showed experimentally on young dogs that a boiled graft could be used with as good success as a fresh one. They mention having applied the method of grafting successfully in 60 cases of spinal disease. Further possibilities were opened by the experiments of Hey Groves and others in the use of boiled beef-bone grafts.

While the whole subject of the share that the actual transplanted bone cells take in the rebuilding of the graft cannot be discussed here, the animal experiments of both Gallie and Robertson, and de Quervain and Hoessly, show how rapidly an autoplastic graft (boiled by the former, fresh in the latter's experiments) is invaded by the bone cells of the part. The time depends on the density of the bone inserted; in the ulna or rib it is about three weeks.

De Quervain and Hoessly partially exsected the body of a vertebra and inserted into the split spines an autoplastic graft from the ulna. They found: (1) That this prevented the formation of a kyphos; (2) That the graft was firmly healed in place in two months; (3) That the segment of vertebral column fixed by the graft, when removed from the body, supported a pressure of 40 kilo. applied to the centrum above the defect. Control dogs, on which the same partial removal of bodies was carried out without grafting, developed a kyphos.

Calvé, in his most interesting paper, which has already been quoted,[7] on the anatomical and pathological changes in the spinal column from the point of view of destruction, displacement, healing, and structural stability, discusses the methods of Albee and of Hibbs as instances of the graft versus the osteoplastic method. He quotes Albee's operation as being eminently satisfactory and practical in the lumbar region, but very difficult to apply in the dorsal region on account of the kyphotic deformity. A strong straight graft will not fit into place, and multiple partial cross-sections make the

graft weak and liable to fracture at the point of the angle where the strength is most needed. He criticizes Hibbs' method in that he has found it very difficult to perform, and when he has performed it, has felt dissatisfied with the prospects of achieving a strong bony union. Calvé himself advocates a method which includes the removal of the spines, the exposure of the laminæ, and the preparation of a broad, raw, osseous surface to which he applies the graft. This is an extensive operation, and one involving the loss of valuable structures.

De Quervain and Hoessly, on the other hand, point out the virtue of a graft method over an osteoplastic method in that the fixation of the spine is achieved so much more quickly and certainly in the former. The difficulty of fitting the ordinary tibial graft to a kyphotic angle has been surmounted by the use of a previously prepared, boiled, human or bovine graft.

The writer agrees with the expression of opinion of Calvé that the Hibbs operation is exceedingly difficult to complete with any certainty of producing a solid union throughout the region affected and the several segments above and below, and further, that it takes longer and involves more hæmorrhage than the graft method of Albee. But those who have seen Hibbs himself perform the operation bear witness to the thoroughness of his achievement and his wonderful realization of a bloodless field.

While the Commission which has been investigation the end-results of the various methods of operative fixation in America is apparently in favour of the operations carried out by Hibbs and his assistants, two factors must be considered before one can apply their findings to the work in this country: (1) The Hibbs operation is very difficult, while the Albee operation is easy except where there is much kyphos. (2) Albee, in his earlier cases at least, seems to have considered that the implantation of the graft eliminated the need for splintage, and allowed his patients to get up without supports within 6 or 8 weeks of the operation; clearly this must have prejudiced his results very seriously. While the writer has had considerable experience of the graft operation, he has little comparable knowledge of the osteoplastic method. Fortunately Hibbs[5] himself has published a detailed account of his operation and a report as to the end-results of 210 cases which had been submitted to operation between January, 1911, and January, 1915, i.e., three years or more before his report. Although the account of the operation given in this paper is very graphic and should be read by any surgeon who is proposing to carry out the method, the writer feels that the technical details of the subperiosteal dissection and exact adjustment of the tiny portions of bone raised from the laminæ are so intricate, and withal so essentially important, that in order to carry out Hibbs' method in its entirety it is probably necessary to see him, or someone who has worked with him, operate. The whole point of this operation depends on the formation of a strong complete posterior plaque of bone, and any incompleteness of interspinous and interlaminal union would lead to failure. In Hibbs' hands the results are extraordinarily good, as the tables on the following page show.

Photographs, radiographs, and tracings were made periodically in each case. Hibbs found that deformity had increased in 18, decreased in 17, and had remained unchanged in 139 cases.

Of 35 cases suffering from cord pressure (26 paralyzed, 9 slightly spastic with increased reflexes), 30 were cured, 2 remained paralyzed, 3 died.

He had no operation mortality, and he states that there was hardly any shock, and that all the wounds healed by first intention. There was no selection of cases, except that the presence of a discharging sinus in or near the field of operation was taken as a contra-indication. Every patient who would consent and whose general condition warranted the anæsthetic was subjected to operation. In only four cases had fusion failed.

One interesting sidelight emerges from this work. Hibbs' operation involves a thorough clearing of the spines and the laminæ right out to the base of the transverse processes, exposing the lateral articulations. He was thus in a position to observe involvement of any of these parts, and in only 5 cases was there disease of spines or laminæ.

This is most interesting in its bearing on the natural processes of interlaminal and interspinal ankylosis. Can the crowding together of laminæ and spines alone produce interunion? It is difficult to imagine that this union would occur between normal periosteum-covered portions of bone. The question is not answered by the segments of spinal column showing dorsal ankylosis in Pott's disease which are to be found in pathological museums, for it is often the most remarkable and unusual specimens that are preserved.

Table I.—Hibbs' Operation. Results in 210 Cases.

Result	No. of Cases
Cured	157 (75 %)
Doubtful	22[1]
Dead	31[2]

[1] 2 have remained paralyzed though the fusion is complete and there is no evidence of active disease.
[2] 13 died of miliary tuberculosis, 5 of tuberculous meningitis, 4 of phthisis, 3 of amyloid disease.

Table II.—Cured Cases. Age at Time of Operation.

Age in Years	No. of Cases
1– 2	2
2– 4	27
4– 6	22
6–10	47
10–15	43
15–20	6
20–30	5
30–40	3
40–50	2

Table III.—Cured Cases. Number of Vertebræ Involved.

No. of Vertebræ	No. of Cases
2	19
3	35
4	23
5	32
6	20
7	14
8	7
9	3
10	2
11	1

Table IV.—Cured Cases. Region Involved.

Region	No. of Cases
Cervicodorsal	6
Dorsal	71
Dorsolumbar	50
Lumbar	28
Lumbosacral	2

REPORT ON 100 CASES.

I have collected particulars of 100 consecutive cases of spinal caries in which operations for spinal fixation have been done by my colleagues or myself at the Shropshire Orthopædic Hospital* or the Headington Orthopædic Hospital in the period 1914–1921. In 95 cases a graft, usually from the patient's tibia, has been applied to the split spines according to Albee's method, or to the bared laminæ. Personally I favour the former. In 5 cases osteoplastic methods were employed. In all but the very earliest cases either a mechanical or motor saw has been used.

Operative Mortality.—Two cases died within a week of the operation. Of these, one, a child of 5, died from shock within twenty-four hours; post-mortem examination showed that the graft had been placed too deeply, was projecting through the laminæ, and pressing on the cord. The other case, a boy of 14, died four days after operation with abdominal pain and hyperpyrexia; the spinal wound was clean; no post-mortem examination was allowed.

In first 50 cases .. .. 2 died
In second 50 cases .. .. none died
Operative mortality = 2 per cent.

Later Mortality.—Six cases are known to have died since :—

Case aged 34 died 4 years later from general tuberculosis
„ „ 28 „ 4 years later from pneumonia
„ „ 6 „ 5 months later from general tuberculosis
„ „ 17 „ 1 year later from shock under anæsthetic during manipulation of hip
„ „ 34 „ 1½ years later from continued caries
„ „ 9 „ 1 year later from tuberculous meningitis

* I acknowledge gratefully the courtesy of Sir Robert Jones, Mr. Aitken, and Mr. Dunn, and the help of Mr. Noble, who will, I hope, publish a full account of the Shropshire cases later.

Age Incidence.—

Ages	First 50 Cases	Second 50 Cases	Total
Under 16	36	16	52
16 or over	14	34	48

Abscess before Operation.—

Abscess palpable but not discharging	24	Clean cases	94
Abscess not present or not recorded	70		
Discharging sinus or sinuses	6	Septic cases	6

End-Results.—Recent reports (December, 1921, or later) of 59 cases grafted 1914–1918 :—

Well	42
Last heard of well, but no recent report available	5
With signs of recurrent or persistent disease	4
Dead (*see* particulars given above)	8

Recent reports (December, 1921, or later) of 41 cases of 'fixation' done 1919 or later :—

Healed and doing well	36
Discharging psoas abscess, but doing well	1
With signs of recurrent or persistent disease (3 of these were previously septic, the other paraplegic)	4
Dead	0

The later results are better than the early ones. This may be due to the following factors : (1) We now always operate in the turning case (*see* figures) ; (2) We keep the patients longer on their frames in the open-air ward before letting them get up and leave hospital ; (3) Our after-care of cases is now more complete.

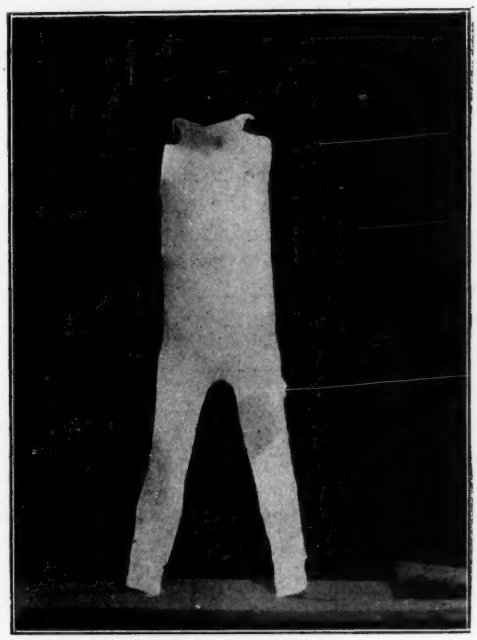


Fig. 295.—Turning case.

After-treatment.—From the first it was realized that graft fixation could not be expected to replace splintage, and that the firm fixation of the graft should not be relied upon for at least three months. The rule adopted was that the case should be treated on a frame for three months subsequent to operation, and then on a spinal support in bed for a further month. It has been found advisable to extend frame fixation in children to six months or more, and in adults to four months, and a spinal support is worn for a year or more after the patient is allowed to get up.

The Turning Case.—This apparatus plays an important part before, during, and after operation in every case. It is essentially a removable anterior plaster-bed (*Fig.* 295) ; it extends from chin to ankles. One of these is prepared for every case of spinal caries that is treated on any form of frame or plaster-bed. It is made with the patient lying on the frame or in the plaster-bed, and is arranged so that it fits accurately over the whole body of the patient, including the legs as far as the ankles, and, in the case of cervical and high dorsal disease, it extends to the chin and mastoid processes. It is always kept near the patient's bed, and is used whenever he has to be turned over for any purpose (*Fig.* 296), for washing, for heliotherapy, or for dressing a wound. If an operation is to be carried out, the turning case is used for the preparation, *during the performance*, and for the after-dressings, of the operation, and the patient lies in the turning case with the frame removed during the operation (*Fig.* 297).

When the turning case is to be used for operation, additional bars are attached to the front of the plaster running up on each side of the head (*Fig.* 298). A strap is put across between these, to support the forehead; this leaves the face held free for the anæsthetist's mask.

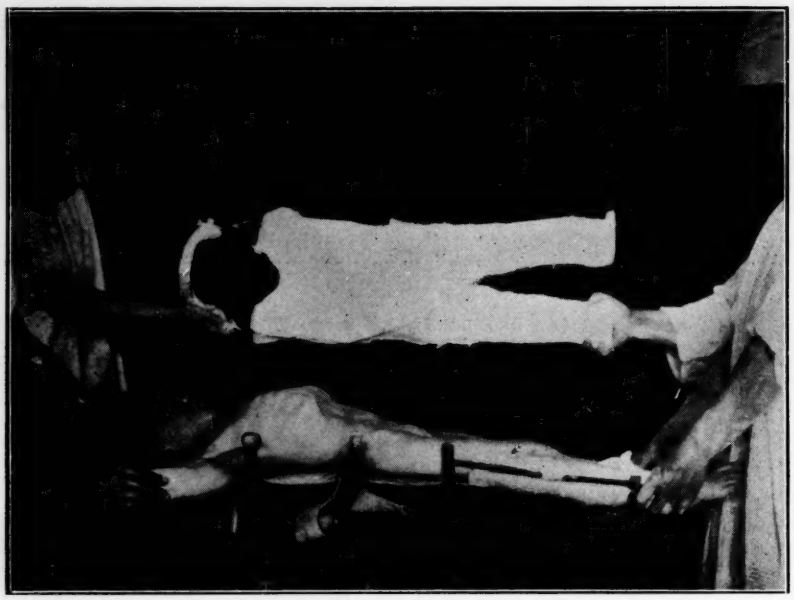


FIG. 296.—Child on frame. Turning case being applied.

The use of these turning cases is the established and fixed routine in both the special hospitals to which the writer is attached, and all the surgeons at these hospitals are entirely convinced of the great advantage and security they provide.

Their use during operations for spinal fixation has practically eliminated all risk of harmful movement of the spine during the operation, and the patients have certainly suffered less often and less severely from shock.

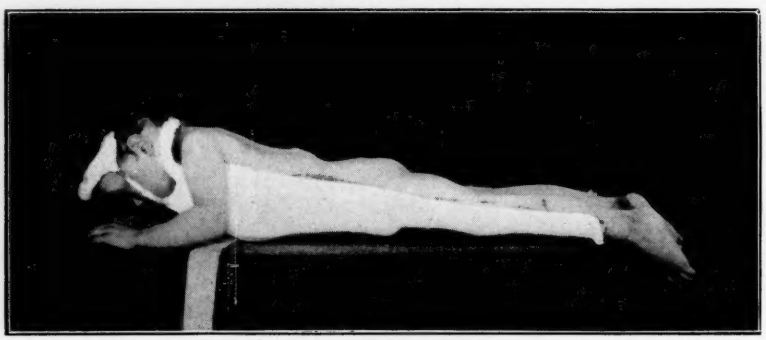


FIG. 297.—Child lying in turning case as for operation.

Suitability of Operative Treatment in Children and Adults respectively.—The end-results have clearly shown that in adults the operation is practically free from danger and leads to good structural stability, but that in children, while in many cases the graft has persisted, in others it has gradually become absorbed. Henderson,[8] discussing end-results of operative fixation (Hibbs and Albee methods), bears out this conclusion. He says: "By repeated *x*-ray examinations of the spine following transplantation of bone in

children we have seen the graft gradually absorb so that there is no trace of it at the end of a year. The same observation also applies to osteoplastic operations." The younger the child, the more often is the graft absorbed. Further, the death of two children has been associated with the operation; in one case this was owing to too deep an implantation of the graft, and in the other unfortunately death occurred a week after operation from an unknown cause.

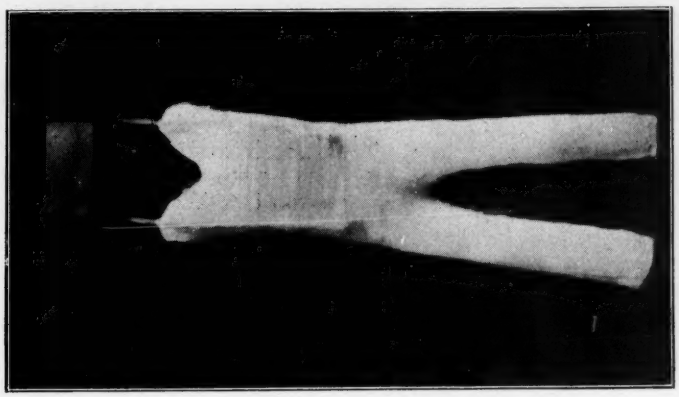


FIG. 298.—Turning case fitted with anæsthetic extension.

In adults, then, grafting is eminently satisfactory, in children much less so. Fortunately, though this limits the scope of the operation, its application is most successful where it is most needed. The main virtues of the operation concern: (1) The early production of sound structural stability; (2) The shortening of the period of recumbency necessary. Now in *children* structural stability will almost always be realized provided a sufficient length of recumbent treatment in an open-air hospital is given. They thrive, and, while their spinal lesion is in process of consolidation, gradually live down their deep-seated lymphatic tuberculosis. Under the provisions of the Board of Education, the children of school age are at school while in bed in hospital, so that there is no educational reason for hurrying or shortening the period of recumbency. In young children, then, grafting is unreliable and not particularly needed. In *adults*, on the other hand, structural stability is seldom really safely realized without operative fixation. Adults do not thrive in general health when laid up in bed for long periods, and can seldom spare so long a time without grave dislocation of their work and depreciation of their earning capacity. In adults, then, successful posterior spinal fixation shortens the necessary period of recumbency and helps to produce permanent structural stability; and in adults both the shortened period of hospital life and the realization of structural stability are of out-standing value.

CONCLUSIONS.

Operations for spinal fixation are in no sense radical. They concern the splintage and permanent stability of the affected part of the vertebral column. The sound healing of the spinal lesion and the effective resistance of the body to tuberculosis must be awaited before treatment is complete. External splintage of the spine must be maintained continuously before operation, during the operation, and afterwards until firm stability of the affected section is assured by the restoration to soundness of the bones and ligaments of the part, coupled with the strong hold of the graft or osteoplastic union.

In adults posterior spinal fixation is reliable, and has great value as "part of the conservative treatment of Pott's disease". In young children it is less reliable, and at the same time less needed, and is therefore seldom, if ever, indicated.

REFERENCES.

[1] GIRDLESTONE, G. R., *Jour. of Orthop. Surg.*, 1919, July, i, No. 7.
[2] WHEELER, SIR W. I. de C., *Practitioner*, 1922, Nov.
[3] ALBEE, F. H., *Jour. Amer. Med. Assoc.*, 1911, Sept.
[4] DE QUERVAIN AND HOESSLY, *Surg. Gynecol. and Obst.*, 1917, April.
[5] HIBBS, *Jour. Amer. Med. Assoc.*, 1918, Oct., No. 17.
[6] GALLIE AND ROBERTSON, *Jour. Amer. Med. Assoc.*, 1918, April 20; and *Brit. Jour. Surg.*, vii, 211.
[7] CALVÉ AND GULLAND, *Rev. de Chir.*, 1920, Oct.
[8] HENDERSON, *Surg. Gynecol. and Obst.*, 1917, May.

PHOSPHORUS NECROSIS OF THE MANDIBLE.

By H. P. PICKERILL, New Zealand.

'Phossy jaw', as phosphorus necrosis of the jaw is called by factory workers, is becoming increasingly rare, since the use of the poisonous yellow phosphorus has been prohibited by law. The present is the only case I have any cognizance of, in which the 'phossy jaw' was acquired through mixing rabbit poison (phosphorus and pollard, etc.).

The patient, a man, age 60, had been engaged for many years in mixing such rabbit poison in Central Otago, New Zealand. About twelve months ago he began to have pain in a lower wisdom tooth; this was extracted, and he went on with his work. About a month afterwards he was sent down to me with a well-marked periostitis and necrosis on the left side of the mandible, which, despite very free incisions and efficient drainage both inside the mouth and under the jaw externally, rapidly spread all round the jaw. The pain during this period was severe, and only morphia controlled it. The acute stage, however, soon subsided, and the tissues settled down to sequestration accompanied by

Fig. 299.—Necrotic 'phossy jaw' removed subperiosteally in four segments and in two stages.

much suppuration, for which free external drainage was provided on both sides of the jaw. The patient's health was maintained at as high a level as possible during this period by a very nourishing diet, tonics, and fresh air. His resistance kept up well and he showed no signs at all of a general toxæmia, which is the cause of fatal termination in such cases.

At the end of six months, judging sequestration to be complete with the development of a considerable involucrum all round the jaw, I proceeded to remove the necrosed bone. This was done in two stages. The left half was removed first in two sections through a long incision below the mandible, the involucrum being split along its lower border to allow of removal of the contained sequestrum; this was accomplished without any very great difficulty. Three weeks later the right side of the jaw was treated in a similar manner, with an equally satisfactory result. It is essential that such cases be left until complete sequestration has taken place, in order to stimulate the formation of new bone; the old method of continual curetting led to disastrous results.

The four pieces of the necrosed mandible, on being put together (*Fig.* 299), showed that the sequestrum consisted of a complete mandible—constituting a somewhat unique specimen.

The patient has made an excellent recovery (*Fig.* 300). Note the small amount of deformity, and the very fair prominence of the chin. This is due to the formation of new bone which is taking place freely. For some time—about a fortnight—he had difficulty in controlling his tongue and preventing it falling back into his pharynx, especially at night, but when the involucrum—new mandible—united again this trouble ceased.

FIG. 300.—Photograph of the patient after removal of the whole of his lower jaw.

The interest in this case centres around several points :—

1. The extensive destruction of bone.
2. The excellent stimulus to new bone formation derived from the presence of the sequestrum.
3. The advantage obtained by not being in too great a hurry to remove the sequestrum, and especially the avoidance of continual 'curettings'.

FIG. 301.—The Frontispiece of the *Fabrica*, 1543.

VESALIUS: HIS DELINEATION OF THE FRAMEWORK OF THE HUMAN BODY IN THE 'FABRICA' AND 'EPITOME'.

By W. G. SPENCER, London.

(*The Fourth Vicary Lecture, delivered at the Royal College of Surgeons of England on December* 14, 1922.)

The Company of Barbers and the Guild of Surgeons of London, after their union in 1540, made special provision for the instruction in anatomy of the members of the United

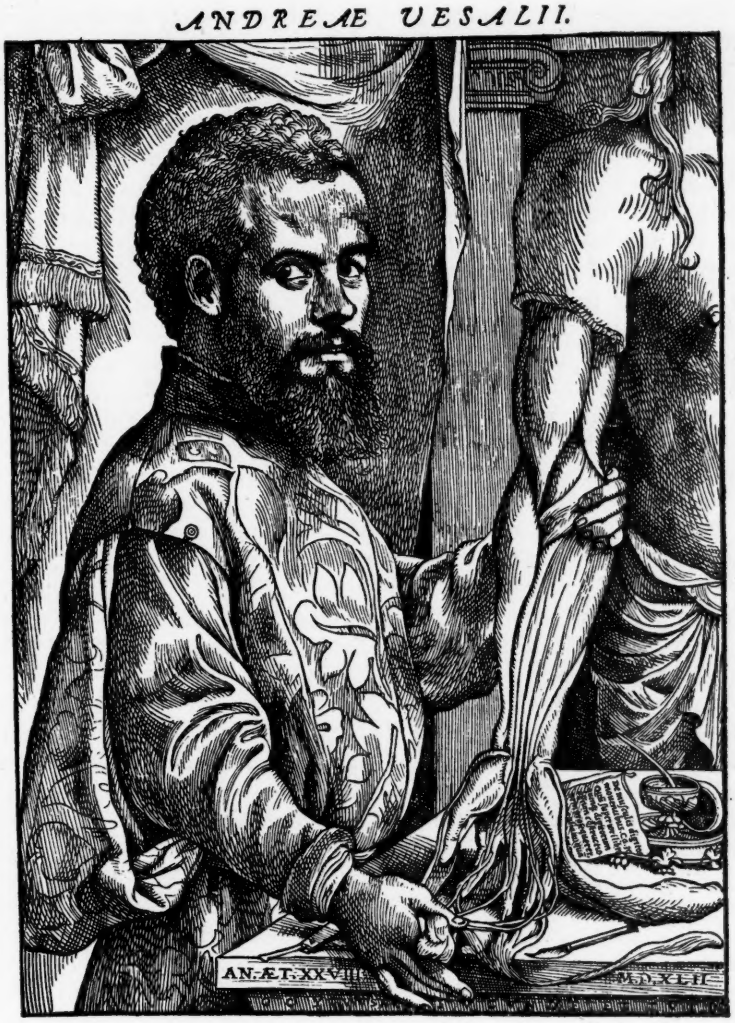


Fig. 302.—Portrait of Vesalius. *Fabrica*, 1543.

Company. In commemoration of this period the Barbers' Company in 1919 instituted the Thomas Vicary Lecture, an historical lecture on anatomy or surgery to be given at the Royal College of Surgeons. Sir John Tweedy, past President of the College and past

Master of the Barbers' Company, was the first lecturer. The second lecturer, Sir D'Arcy Power, Vice-President, has made notable contributions to the history of the Guild of Surgeons. The third Vicary Lecture was given by Sir Charles Ballance on the history of trephining and of brain surgery.

The natural prejudice against the examination of human bodies after death had prevented the art of medicine from developing beyond the stage reached by the Greeks; with the Revival of Learning, however, the human mind became more open to reason, so that a knowledge of structure and of function, also of the changes caused by disease and accident, was obtained by examining human bodies after death, and in addition, anatomical specimens began to be preserved in museums. Supplementary to this was the knowledge acquired by experiments on animals. As the study of human anatomy and physiology increased, it was made the more widely known by the art of printing; there further developed an increased skill in making anatomical drawings, which were then reproduced as illustrations by engraving on wood blocks and copper plates.

Thomas Vicary, the first Master of the United Barber Surgeons' Company, was surgeon to St. Bartholomew's Hospital, also to King Henry VIII and his successors, Edward VI, Mary, and Elizabeth; moreover, in 1554 he was appointed surgeon to Philip II of Spain.

At the time corresponding with the painting by Hans Holbein of the famous picture which adorns Barbers' Hall, Vesalius was preparing his great work the *Fabrica*, together with its *Epitome*, both of which were published in the summer of 1543. After that Vesalius succeeded his father as surgeon to Charles V, and when that emperor abdicated, he transferred his services to Philip. Thus, in quite different ways, both Vicary and Vesalius came to hold the appointment of surgeon to Philip II of Spain.

The year 1914 was the 400th anniversary of the birth of Vesalius and the 350th of his death. It had been proposed to celebrate his memory at the end of that year, but when that time arrived, Brabant, and Brussels, his birthplace, were in the hands of the enemy, whilst the Library of the University of Louvain, at which Vesalius was educated, had been burnt, together with examples of his works. In neutral Holland, however, especially at the University of Leiden, where Vesalius has always been held in honour, several communications concerning him and his writings were published (*Janus*, 1914, Vol. xix). About the same time, in an oration delivered before the German Anatomical Society, Dr. Holl of Graz commented on the description of the brain by Vesalius (*Archiv. f. Anatomie*, 1915, s. 115). In America, Dr. Cushing and others exhibited and discussed several of his writings. In this country, Mr. H. M. Spielman had in course of preparation an *Iconography* concerning the portraits of Vesalius which the Belgian Government intended to publish, but which were afterwards sent to America (communication by letter).

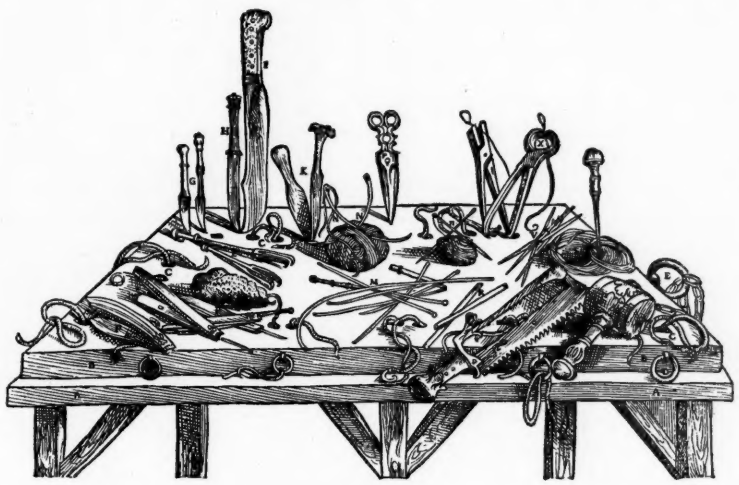
If a reason for selecting the subject of this lecture need be given, it may be noted that this year there has been celebrated the foundation of the University of Padua, where from December, 1537, to August, 1542, Vesalius taught as the first Professor of Anatomy, whilst composing his books.

There has accumulated a mass of literature about Vesalius—'Vesaliana'—but all that is well established about him and his illustrations is based essentially upon his own statements; nothing beyond that can be deemed authentic. In 1892 Dr. Roth of Basel published an important study of the writings of Vesalius (M. Roth, *Andreas Vesalius Bruxellensis*, Berlin, 1892). His enthusiasm, however, led him into some exaggerations which provoked criticism. Since Roth's book, Leonardo da Vinci's drawings have been reproduced, and were described by Professor William Wright in his Arris and Gale Lectures, 1918.

The anatomical illustrations contained in mediæval manuscripts can be examined in Professor Sudhoff's Collection (K. Sudhoff, *Ein Beitrag zur Geschichte der Anatomie im Mittelalter*, Leipsig, 1908). They consist of diagrams, largely imaginary, no better for the most part than the drawings of untaught schoolboys. Of those in printed books, the best, perhaps, are to be found in Berengario da Carpi's *Commentary on Mundinus*.

The great Italian artists in the fifteenth century, under the patronage of princes and popes, studied human anatomy by dissection, and made drawings from anatomical preparations. Pallaiuolo (1429–98), an elder contemporary of Leonardo, whose Martyrdom of St. Sebastian in the National Gallery shows semi-nude male figures, dissected many bodies in the course of examining muscular outlines, and eight drawings by him are in the Louvre. Leonardo da Vinci (1452–1519) stated to Antonio Beati in 1517 that he had dissected more than thirty men and women of all ages ; the first date relating to his anatomical studies is April 2, 1489. Whilst his paintings became so well known, he did not publish his anatomical drawings ; there is no evidence as to any influence upon Vesalius, and they did not receive attention until recently. Further, Albrecht Dürer (1471–1525), Michael Angelo Buonarotti (1474–1563), Titian (1477–1576), Della Torre (1482–1506), Raphael (1483–1520), Hans Holbein (1497–1543), all to some extent studied artistic anatomy by the aid of human dissection previous to Vesalius.

In December, 1537, Vesalius went to Padua, and after passing the examination for the degree of Doctor of Medicine, was, on the day following, appointed by the Government



QVADRAGESIMIPRIMI CAPITIS FIGVrarum,eiuſdemq; characterum Index.

FIG. 303.—Apparatus used in dissecting by Vesalius.

of Venice 'Lector, Ostensor et Incisor', a post which marked the commencement of a separate professorship in anatomy. Early in 1538 he published a revised edition of the *Institutiones Anatomicæ* which Günther von Andernach had extracted from the writings of Galen. In order to explain to students Galen's statements he issued at the same time his *Tabulæ Anatomicæ*. These were distributed as loose sheets, and hence have all disappeared except two collections of six sheets each. One collection was reproduced in full size by Sir William Stirling Maxwell in 1874. The other extant collection is preserved in the library of St. Mark's, and was reproduced in three-quarter size by Dr. Holl of Graz and Professor Sudhoff of Munich in 1920. Thus this early production by Vesalius has been made well known ; but it should be recognized that the intention was to illustrate Galen's statements. Subsequent to that publication Vesalius extended his knowledge of human anatomy and undertook with greater boldness the correction of Galen's statements derived from dissecting monkeys and other animals. Comparison with the drawings in the *Fabrica* and *Epitome* serves to show the advance in human anatomy made by Vesalius whilst at Padua. In the course of four and a half years, and before he had completed his twenty-eighth year, he had finished his great work. The *De Humani Corporis Fabrica* is

EXTERNARVM HVMANI CORPORIS SEDIVM PARTIVMVE

HIC NON prolixior nominum externas hominis sedes locaue indicantium enumeratio instituitur, quàm cõmodè imaginũ uirilis muliebrisq; corporis superficiẽ exprimentiũ marginibus adhiberi potest. Quanquam succinctam eorum descriptionem, ac uelut præsentium figurarum indicem duntaxat proponere nihil obstet, quum eadem ferè nomina externis corporis sedibus ac ossibus, partibusque externæ sedi subditis, accommodentur, quorum præcipua, ab ijsq; qui rectiùs dissecandi rationem aggressi fuerunt instituta, iam prius in orationis contextu, quantum proposita nobis Epitome requirit, recensuimus. Solet itaque uniuersa corporis superficies ab illius nominum institutoribus primùm in magnas sedes diuidi, ac dein illarum partes rursus uarijs nomenclaturis donari. Atque ita Ægyptij medici corpus in [a] Caput, [b] Thoracem, [c] Manus, & [d] Crura diuidebant: Thoracem, perinde ac Aristoteles, nominantes, uniuersum corporis [e] truncum, à iugulo aut collo clauiculis ue ad inguina & pubem, aut magis ad femorum usque superiora pertinentem: non autem tantum, ut Galenus, nonnullisq; Anatomicorum primarij, corporis sedem costis septam. Alij facultatum corpus uniuersum dispensantium, animarumq; sedibus mentem adhibentes, quadrifariam quidem similiter ac Ægyptij corporis superficiem discernunt, uerùm secus quàm illi corporis truncum in duas sedes primùm distinguẽtes, manus & crura unius partis loco prima hac diuisione enumerãt, illa quæ [f] Artus propriè uocatos constituunt, extremorũ nomine complectẽtes. Ac in corporis trunco duas præcipuas locant sedes, secundùm duas cauitates secantibus inibi obuias: quarum inferior ab elatiori, interuentu septi transuersi seiũcta, iecur naturalis altricis ue animæ sedem sanguificationisq; officinã, ac insuper huic subministrantia organa complectitur, partibus quoque generationi famulantibus parata. Superior cauitas cordi irascibilis animæ fomiti uitalisq; spiritus fonti, illiq; subseruientibus organis ascribitur. Cæterùm tertia corporis cauitas capiti tribuitur, cerebro´que potissimùm principis animæ sedi, animalis´que spiritus promptuario sacratur. Corpore in hunc modum obiter diuiso, singularum partium superficies ita rursus distinguũtur, ut capitis totius pars anterior supercilijs superposita, ac [g] crinibus nuda, [h] lineas´que quasdam proponens, [i] Frons nominetur. Hac superior & uersus capitis medium uergens, [k] Sinciput. Vtrinque ad sincipitis latus, supra´que [l] Aurem, cui [m] Auditorius meatus inest, consistens, [n] Tempus. Media capitis sedes sinciput uersus posteriora superans, [o] Vertex, qui ueluti centrum est [p] circuli crinium originem circunscribentis. Post uerticem usque ad musculorum qui utrinque in ceruicis summo prominentes, in medio foueam ostendunt, ac pleriſq; [q] Tendines dicuntur, elatissimam sedem [r] Occiput spectatur. Prior autẽ capitis pars à frõte ad mentũ usq; protensa, [s] Facies. Inferior enim frõtis pars, [t] Supercilijs ueluti eminẽtibus, pilisq; cõsitis terminis, eorundemq; [u] medio circunscribitur. His subsunt [x] Oculi, inferiùs & superiùs [y] Pãlpebris intecti: quarum sedes ubi inuicem conniuent, & erectis ordinata´que, ut in nauibus remos spectamus, serie positis pilis, quos [z] Cilia nuncupamus, ornatur, quo dammodo´que cartilagineæ sunt, [a] Tarsi habentur. Commissionis huius termini, [b] Anguli sunt: quorum maior nasum, minor tempus spectat. In disiunctarum palpebrarum medio præter [c] Carunculam in maiori angulo conspicuam, [d] Album candidum´ue oculorum apparet: in cuius medio duo se offerunt circuli, quorum amplior [e] Iris & Corona est, minor [f] Pupilla. [g] Nasus oculos interiacet, cuius foramina [h] Nares uocantur: quarum externa latera nasi [i] Pinnulis seu Alis, interna uerò [k] Interspto nasi constituuntur. Sedes ad nasi latera mali in modum prominulæ

FIG. 304.—A page of the *Epitome*.

CITRA DISSECTIONEM OCCVRRENTIVM APPELLATIONES.

minulæ ac rubentes, 'Malæ, & quibuſdam Genæ uocantur. Sedes inter naſum & malas mediæ nonnullis "Concaua dicuntur, quo nomine alij totam oculorum "ſedem à palpebris ad malas metitam uocarunt. Faciei pars quam inflamus "Bucca eſt. tota uerò ipſius pars à ſupercilijs ad elatiorem uſque dentium ſeriem pertinens, 'Superior maxilla nominatur, reliqua autem quæ in uiris "Barba decoratur, 'Inferior. cuius anterius extremum, 'Mentum nonnunquam 'ſoueа orna tum educit, ſub "Labri inferioris rubore conſiſtens. "Elatioris labri ſedes naſo ſubdita, 'Sulculoq; donata, "Muſtax cenſetur. Quod labris circunſcribitur & continetur, "Os, quo hiante "Lingua, "Palatū, "Gargareon, 'Dentes, 'Gingiuæ, internaq; "Faucium ſedes occurrit. Quod caput ad clauiculas uſq; aut thoracem excipit, "Collum & Ceruix eſt, & ſi poſterius nomen magis poſteriori parti accommoderur, uti & anteriorem qua aſpera arteria, & potiſſimùm ipſius 'caput tangentibus occurrit, Guttur dictam legimus. "Humerus ueteribus uocabatur brachij oſſis cum ſcapula articulus, unde & partem maximè ad colli radicem thoracisq; latera eminentem, 'Summum humerum dixerunt. Quod ab illo prorſum uerſus "Iugulum ſoueam'ue in colli radice obuium uergit, "Clauicula eſt. Quod autem ab ipſo ad extremā digitorum aciem protenditur, "Manus: cuius prima pars (ſub qua cauitas "Axilla aut Ala appellata, & muſculis quos "Tendines permulti illic uocant ſepta, conſtitit) ad proximum uſque articulum 'Cubiti'ue flexum producta, 'Brachium, & Latinorum quibuſdam Humerus dicitur. Poſterior flexus illius ſedes 'Gibberus eſt. Pars ab hoc ad conterminum articulum ducta, "Cubitus, & Latinorum quibuſdam Brachium & "Vlna. Ad cubiti extremum 'Summa manus incipit, cuius pars à cubito ad quatuor digitorum radices porrecta, in duas ſedes partitur: ac cubito propinquior "Brachiale eſt, alia 'Poſtbrachiale, quæ à conſtructionis ſpecie cum pectore etiam "Pectus, à quibuſdam Palma nuncupatur. Huius interior ſedes caua ac uarijs monticulis ſepta, multisq; lineis interſtincta, 'Volam efficit. Reliqua ſummę manus pars, 'Digiti ſunt, ſinguli ternis 'partibus tanquam in acie locatis efformati, & exteriùs 'Vnguibus ornati. Horum maior alijsq; actione oppoſitus "Pollex eſt, illi proximus "Index, dein 'Medius ſeu Impudicus, cui proximus eſt "Medicus & Anularis. Eximam uerò ſedem occupat 'Paruus, Auricularis'ue. "Thoracem hîc nominamus corporis trunci partem "Coſtis ſeptam, maximamq; ſedem "Laterum efformantem: cuius anterior ſedes "Pectus eſt, quam "Mamillæ, alijq; in illarum medio 'Papillæ cum obfuſco ipſas ambiente' circulo occupant. Reliqua anterior trunci ſedes 'Abdomen conſtituit, cuius regio pectoris oſſis cartilagini & coſtarū cartilaginibus illa humilioribus proxima, perinde "Subcartilaginea nuncupatur, ac uiſcera cartilaginibus illis complexa. Sic quibus ſeptū tranſuerſum præcordia appellatur, ſedes in quam id cartilaginibus inſeritur, Præcordiorum nomen obtinuit. quanquam rurſus alij ita etiam thoracis anteriorem ſedem nuncupent. Quod ſub infimis coſtis & ilium oſſis ſpina (quę mulieribus multo magis quàm uiris eluciur) oſſibus deſtituitur, tangentibusq; cedit, "Inania ſunt & 'Ilia. in quorū ueluti medio "Vmbilicus cernitur, ſub quo mox 'Sumen, cuius infima ſedes trunci terminq proxima, "Aqualiculus nuncupatur. Terminus autem ubi hic 'Pudenda & Naturalia conſiſtunt, "Pubes eſt & Pecten, ad cuius latera in femorum flexu 'Inguina recenſemus. Maris pudendi pars citra ſectionem conſpicua, 'Penis & Coles uocatur: cuius ſummitas magis quàm reliqua longitudo craſſeſcēs, "Glandem efformat, in cuius medio meatus urinæ ſeminiq; communis conſpicitur. Huius inuolucrum "Præputium eſt, ſicet alijs tota penis ſummitas ita nuncupetur. In inuolucro reliquaq; ad anum cute protuberantē futuræ modo lineam uocamus 'Suturam, & totam hāc exporrectam extuberantemq; ad anum uſque penis partem "Taurum. Vti & ſedem inter teſtium inuolucrum (quod ex cute paratum 'Scortum dicitur) & anum conſpicuam, "Interfeminium nuncupamus. Muliebris pudendi rima, quæ uteri ceruicis eſt orificium, "Sinus uocatur, quem "Alæ & Colles utrinque prominentes, & cuticularis in ipſius ſummo apparens "caro ornant. Recti inteſtini orificium per ſedem prodiens, à figura "Anulus, & ab officio 'Strictor appellatur. Poſterior trunci corporis pars, 'Dorſum aut Tergū ferè nuncupatur, cuius latera in elatiori poſterioriq; thoracis ſede 'Scapulis conſtituunt. Inter ipſas uerò mediū & dorſi ſedes hinc ad infimas uſq; coſtas, aut 'ubi id maximè in flexu protuberat, pertinens, thoraci aſcribit, ac poſt ſeptum tranſuerſum conſiſtit. Sedes uerò hanc ad nates uſq; ſequens, 'Lumbos cōplectitur. Sunt autē "Nates carneæ & globoſæ ſedes, iliū oſſiū occupātes dorſum, in quarum medio ſacri oſſis & coccygis poſteriores proceſſus uelut excarnes ad anū uſq; occurrunt. Vbi articulus femoris percipitur, magnusq; 'Rotaror exuberat, "Coxendix eſt, aut Coxa, quod nomen alij 'Femori aſcribunt, ab inguinibus ad "Genu pertineni: cuius poſterior ſedes & flexus 'Poples nuncupatur. Genu ad proximum uſq; articulum pedis'ue initiū 'Tibia ſubſequitur, quæ nōnullis Crus nominatur, & ſi pluresid nomen ſimul tibiæ femoriſq; uelint eſſe cōmune. "Anterior tibiæ ſedes oſſea tangētibus occurrit, poſterior autē ubi ipſius "Venter ſeu Sura cernitur, carnea. Tubera ad tibiæ imū utrinq; uelut oſſea tangētibus obuia, 'Malleoli, neutiquā uerò 'Talus illis exceptus reconditusq; nominatur. Poſtica pedis pars extra tibiq; rectitudinem retrorſum prominens, 'Calx appellatur. Reliquę uerò pedis ſuperficiariæ ſedes prorſus oſſium nomenclaturā aſſumunt, potiſſimū autē "Tarſi, 'Pedij ſeu 'Pectoris, quod digiti hîc etiam unguibus ornati ſequuntur. Quanquā ubi de integro pede ſermo inſtituitur, infima ſedes qua calcamus plerunq; Planta, & 'Veſtigium, ipſiusq; internū latus "Concauū, ſuperior uerò Tarſus nuncupetur.

FIG. 305.

a work of 759 folio pages with more than 320 wood block engravings, all arranged to correspond with the course of anatomy as given by Vesalius. It contains an account of human anatomy and physiology based essentially on the writings of Galen, the final chapter including a condensed description of Galen's experiments on animals, with a repetition of which Vesalius ended his course. The term '*fabrica*' had been used by Cicero in his *De Natura Deorum* several times, meaning 'framework', 'fashioning', 'workmanship'. Vesalius claimed that he had corrected 200 of the errors which Galen had imported from animal anatomy; it is needless to say that he left a great number uncorrected. But there is a new edition of Galen's writings in course of publication; meanwhile, what Galen actually wrote on various points, and the interpretation to be placed on certain passages, may be regarded with a suspension of judgement.

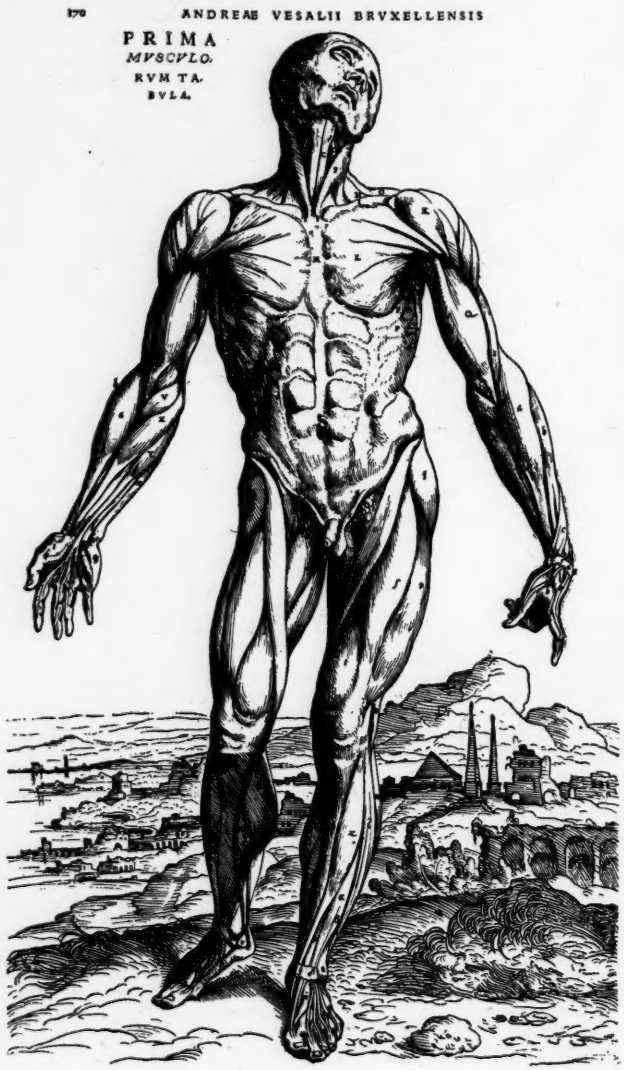


FIG. 306.

The origin of the illustrations in the *Fabrica* and *Epitome* has been discussed at great length; the only conclusions which are at all certain are that all are original and all must have been designed by Vesalius himself. Even his opponents, Jacobus Sylvius, Colombo, Fallopio, whilst calumniating him as bitter enemies in relation to his variations from Galen, gave no hint whatever as to any copying either of illustrations or of text. Discussion has failed to establish any direct influence of the great artists who preceded him. The recent publication of Leonardo's drawings fails to suggest any relation with those by Vesalius. Leonardo for the most part dissected old people; one of his more finished drawings, viz., the lateral view of the spine, shows lipping of the bodies of the vertebræ and thinning of the intervertebral discs, changes which Vesalius noted as productive of senile kyphosis. Vesalius made it his particular aim to take his illustrations from well-nourished young adults. He quoted from Celsus the *corpus quadratum*, 'square-built', neither spare nor fat, as being fittest for illustrative purposes. Executions not only of young men, but also of young women, were frequent, and thus he was able to obtain muscular bodies for dissection.

As regards the illustrations, some are well finished, some incompletely so; a great number are schematic figures or diagrams primarily intended to explain statements in the text, statements in some cases made by Galen which Vesalius then proceeded to correct. The closest relation exists between the text of the *Fabrica* and the illustrations,

and both must be always considered in relation to the dissected preparation upon which they were based. The whole text and illustrations are linked together by an elaborate scheme of cross-references, together with thousands of marginal notes, differing according as they are printed in the inner or outer margins. The more thoroughly such points are reviewed, the more irresistible becomes the conclusion that all the illustrations must have been designed by Vesalius himself.

As to the artists who made either the preliminary sketches or the actual drawings on the wood blocks, there were then in Italy a great number of artists of the second rank, assistants, pupils, and copyists of the great masters. Vesalius did not say who were the draughtsmen or who the wood engravers. Indeed he only mentioned by name two artists, and that incidentally, without definitely attributing anything to them, Van Calcar and Nicolo Stupio. Jan Stephan van Kalkar, Joannes Stephanus Calcarensis (1499–1546), a native of Calcar in the Duchy of Cleves, was at Venice in 1536, where he perfected himself in the style and manner of Titian and Raphael so as to deceive even experienced critics. Whatever part he took in association with Vesalius lay between 1536 and 1539, after which he went to Naples, where he was engaged in painting until his death in 1546. In the dedication of the *Tabulæ Anatomicæ* Vesalius speaks of him as a "distinguished painter of the day". In a footnote appended to the three skeleton figures, it is stated that they had been printed at Venice by B. Vitalis, a Venetian, at the expense of Joannes Stephanus Calcarensis, and were on sale at the shop of D. Bernardus. In the *Epistola de vena secanda*, p. 66, Vesalius said, "provided that he (Vesalius) could get anatomical specimens and that van Calcar would not disappoint him as to drawings so that he might escape the labour of himself making the drawings . . .". Beyond these remarks of Vesalius, there is an enormous literature, concerning which all that need be said about the numerous conjectures is that they are mutually destructive.

FIG. 307.

Vesalius did say that the preparation of the dissections, and the direction of the eye, hand, and intelligence of the artists, had cost him a monstrous amount of labour. He complained bitterly of the more than wayward caprice of both draughtsmen and wood

engravers. He regretted that he had had to pay such large sums to induce skilled artists, more interested in painting Venuses and Graces, to draw pictures of skinned and foul-smelling bodies. The drawings and engravings were carried out at Padua and Venice. Vesalius watched over their preparation; at Venice he arranged the artist's proofs between the sheets of the text, before their despatch to Basel, in order to prevent mistakes in the arrangement by the printers. He himself followed and spent the best part of a year at Basel superintending the printing.

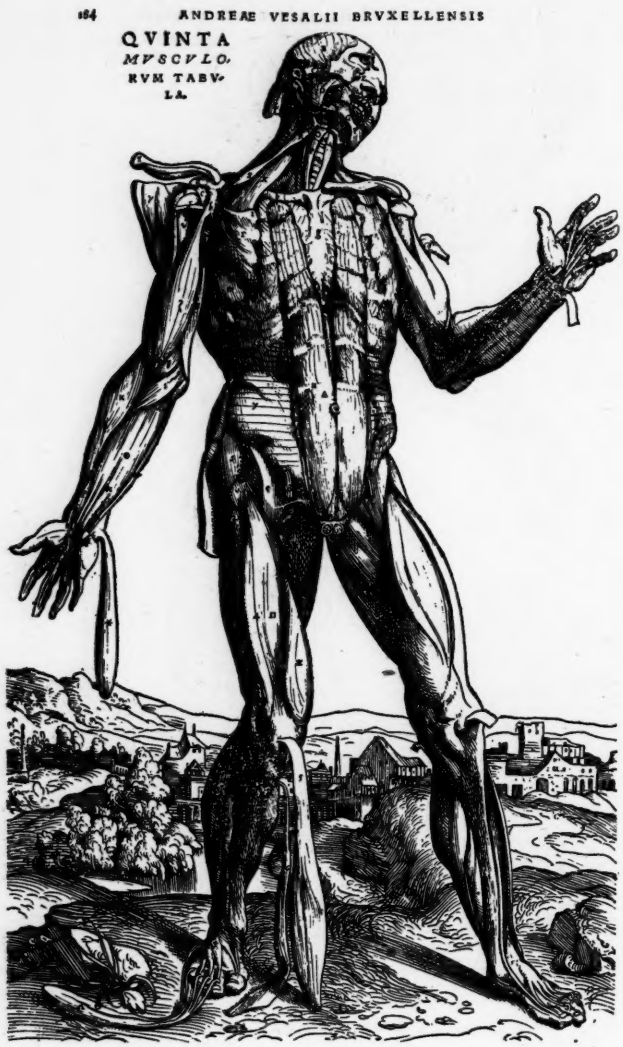


FIG. 308.

The Frontispiece (*Fig.* 301). —Vesalius, in the frontispiece which constitutes the title-page both of the *Fabrica* and the *Epitome*, gave a pictorial representation of his anatomical instruction. He is depicted conducting a Public Anatomy in a covered hall, lighted from above, with an apse and gallery, the architecture reminiscent, on a small scale, of St. Peter's. For anatomy was a subject worthy of presentation in a noble apartment accommodating a large and general audience, rather than in a private room to a few doctors, or worse still in a mortuary cellar, temporary shed, or even in the open air. It is recorded in the archives of the University of Padua that an audience numbering 500 attended from the beginning to the end of his demonstrations.

High up in front of the centre of the apse is the coat of arms of Vesalius enclosed in a crown of laurel, three weasels, one under the other, indicating his descent from landed gentry and tracing the derivation of his name from the place Wesel; *Wesel* or *wesele* is the Flemish for weasel, and Vesalius spoke of *meæ mustelæ*. The coat of arms is supported by cupids, representing the medical students as in the Vignettes, who are gazing sidelong at prostrate satyrs, like gargoyles, his enemy critics. Underneath is a mask such as Greek actors used, for Vesalius would have the structure of the human body widely known. Vesalius is standing on the right side of a table upon which is lying a female cadaver with the abdominal viscera exposed. He is holding up his left index finger to require attention, whilst without a book he teaches anatomy directly from the dissected part. A reader, seated at a high desk, and expounding a passage from a classical author, has been superseded. Vesalius in his right hand holds a rod with which to demonstrate the object he is referring to, for he has done away

with a separate 'ostensor'. Further, he is carrying out the dissection himself, the attendant behind him being engaged in keeping his knives sharp. Whilst he thus encouraged personal dissection, he made scornful allusion to physicians too delicate to handle anatomical material. At the head of the table is an articulated skeleton, and under the table are separate bones on a tray. The audience is a mixed one : there are old bearded men in robes and sandals, representing philosophers, followers of Aristotle who had taught whilst walking round the Lyceum Gardens in Athens ; their need was to acquaint themselves with human anatomy in place of the anatomy of animals found in the writings of Aristotle and Galen. Wealthy townsmen supported public anatomy, and one of them is holding up before his eye a biconcave lens, a very early representation of the use of such an aid to distant vision. Peeping round a pillar is a fashionably dressed youth, in slashed hose There are nuns, one in the foreground being nudged by a bystander, the other keeping more in the background ; also there are monks close behind Vesalius ; Vesalius would imply that these had come to the Anatomy out of curiosity about the female genital organs ; he had more than one gird at the interest the celibate clergy took in the subject of generation ; theologians talked much more on this subject and its details than did medical men. Peeping round an opposite pillar is the nude figure of a well-developed young man from which Vesalius demonstrated the contours on the surface produced by the muscles, whether in movement or at rest. In the foreground the chattering tailed monkey calls to mind Galen's anatomical descriptions, and the dog on a leash the animal experiments with which the course was completed. Before the table, seated on the ground, are two gravediggers arguing over the division of the money received for providing the cadaver, a subject further illustrated in the Vignettes.

FIG. 309.

The Portrait (*Fig.* 302).—The portrait of Vesalius is reproduced in both the *Fabrica* and *Epitome*, and the same block was evidently used three years later for the reproduction in the *Epistola de radicis chynæ*, by which time it had become much worn. It, together

with the figure in the frontispiece, are the only two authentic representations of Vesalius. It is dated 1542, he being then aged 28. There is no signature or other mark of the artist, and there exists no authoritative statement on this point. The only thing worthy of note is that the frontispiece figure differs from the portrait, and in the second edition of the *Fabrica* in 1555 an attempt seems to have been made to alter it to an appearance more like that in the portrait. The portrait is so characteristic that it is impossible to mistake it for that of anyone else. It may, however, be a question how far the artist has deviated towards caricature by drawing the tip-tilted nose, the keen eyes, the high forehead, the large head, the short arm, the pudgy hand, and tapering fingers. In the frontispiece the hands are drawn fine and well proportioned, more fitting to one skilled in handicrafts.

FIG. 310.

Vesalius is standing holding up the dissected right arm of a well-developed female. Before him is an opened page, such as he was then engaged in writing, dealing with the muscles moving the fingers. There is here a suggestion of the triple relation between the text, the illustrations, and the dissected part. It was a region which Galen had treated superficially, owing to its small size in the monkey.

On the side of the table is the motto "*Ocyus, jucunde et tuto*." Celsus, quoting from Asklepiades, wrote "*ut tuto, ut celeriter, ut jucunde curet*" (to treat with safety, speedily, and pleasantly). Vesalius applied the quotation to his teaching of anatomy, but the variation from '*celeriter*' to the latinized form of the Greek ὀξύς may be based on a tradition different from that through Celsus.

The Vignettes enclosing the Capitals.—In the vignettes Vesalius included a remarkable series of thumbnail sketches, which, whilst superficially they form humorous skits on the medical students, portrayed as fat naked boys, cupids, and amoretti, are of great historical interest, because they indicate the difficulties attending the pursuit of anatomy, and incidentally enforce the importance of personal dissection of human cadavers as well as of animals.

The large initial '*Q*' of *Quantumvis* ('however much soever'), which commences the preface of the *Fabrica*. dedicated to Charles V, depicts the vivisection of a young pig; one cupid is reading out of a book, whilst another is cutting into the animal's neck in order

to repeat one or other of Galen's experiments, either the division of the vagi nerves to show their control of the voice, or the performance of tracheotomy and the examination of the mechanism of breathing.

The vignette enclosing the large capital 'I' shows cupids disinterring by candlelight a stout cadaver; one cupid dressed out in imitation of a Roman soldier with helmet and spear, is on guard as a sentinel, another serving as a scout is running up holding a flag, to give an alarm. The large 'O' shows cupids macerating a skull by boiling in an iron pot hanging over a wood fire. Vignettes enclosing smaller capitals represent cupids catheterizing one of their number, disinterring and breaking open a coffin, sawing open a skull, putting a fractured leg into a glossocomium or box splint, applying the cautery over the temporal artery through holes in a plate. There are also sketches of cupids performing paracentesis abdominis on an old man; taking down from the gallows a female cadaver; inflating a stomach to demonstrate the fibrous coat; carrying off in procession with triumphant steps a cadaver for dissection; taking down from the top of a pole a decapitated head; studying an articulated skeleton; examining the abdominal viscera; removing the eye from the head of an ox; and performing venesection. These sketches are not scattered arbitrarily, but are related to the text which follows the respective capitals.

FIG. 311.

In the vignette of the large 'V' forming the initial letter in the preface of the second edition there is a hit at his critics. The Phrygian Marsyas, who had ventured with his flute to match himself against Apollo and his lyre, is being skinned alive, whilst two nymphs look on. At the back of the *Fabrica* Arion with his lyre, after being cast overboard, is riding on the dolphin's back. This is varied in the second edition, where it is represented that the dolphin has brought Arion safely to land.

Instruments used in Dissecting.—Some of these are seen on the table in the frontispiece. Vesalius exhibits in various passages an extensive acquaintance with handicrafts of various kinds. One chapter is devoted to the instruments employed in dissecting, and some thirty are drawn lying on a table (*Fig.* 303): knives like razors or

dinner knives, penknives, also knives shaped out of boxwood and ebony for dummy operations; two-pronged sharp hook retractors; probes and probe-pointed directors and cannulæ; needles, strong curved chisel-ended as used in bookbinding, also smaller triangular and spear-ended as used in surgery; a strong butcher's saw; scissors in shape like tailors', sharp-pointed; a wooden mallet; hollow reeds for inflating the lungs and other organs; brass wire for articulating skeletons, along with awls of various sizes fitting into a common handle, pincers for twisting up and nippers for cutting the wire. There are no anatomy forceps; Vesalius used his fingers, including his finger-nails; chain hooks were a later invention.[1]

FIG. 312.

The Muscle and Skeleton Figures.—The illustrations designed by Vesalius for the purpose of delineating the muscles and skeleton form a remarkable series. There are in the *Fabrica* sixteen muscle and three skeleton figures; in the *Epitome* two nude figures and five of the muscles, all drawn from well-developed young adults. It is a special mark of the genius of Vesalius that he succeeded in portraying the muscles as if in the state of contraction required to produce the particular position given to the figure, and the skeletons suggest life and movement. The position and balancing of the head, trunk, and limbs vary with each figure, and by cross-references an interrelation between the different figures is established, so that each muscle is presented from several points of view. If we direct particular attention to movements of the arm at the shoulder-joint, or to those of the leg at the knee and ankle, the various illustrations taken together serve to analyse the way in which such movements are produced. Vesalius was accustomed to demonstrate as many as forty muscles one after the other. The figures are drawn in correct proportion, being reduced in the *Fabrica* to one-fifth of the natural height, viz., to 340 to 345 mm.—i.e., one-fifth of 1700 to 1725 mm., the average height of a man. In the *Epitome* the reduction is to one-quarter, the figures measuring 425 to 430 mm. in height.

The male and female nude figures (*Figs.* 304, 305) produced in the *Epitome*, although from an artistic point of view they bear comparison with such earlier (A.D. 1504) woodblock engravings as Dürer's 'Adam and Eve', were in fact designed to conform with the other figures. The contours on the surface of the male nude exhibit the effect of the contractions of muscles in correspondence with the positions in which the head, trunk,

and limbs are portrayed. These muscles are shown in the muscle figures after their exposure by dissection. The female nude, whilst in some respects resembling Greek models, is in general designed to serve as a contrast to the male nude in respect to the positions of the head and limbs. Although, as compared with the male, the surface contours are smoothed down, the shading produces the external appearance of a young adult woman. But Vesalius had a further design for the figure, which he adapted for the superposing of the diagrams to be referred to later. There are no letterings to blur the surface of these nude figures, for the width of the page in the *Epitome* permitted of a brief naming of superficial positions in a column of text printed alongside each figure. Whether on his living subject, or on the cadaver before the actual commencement of dissection, Vesalius was accustomed to sketch the outline of the bones, superficial veins, etc.

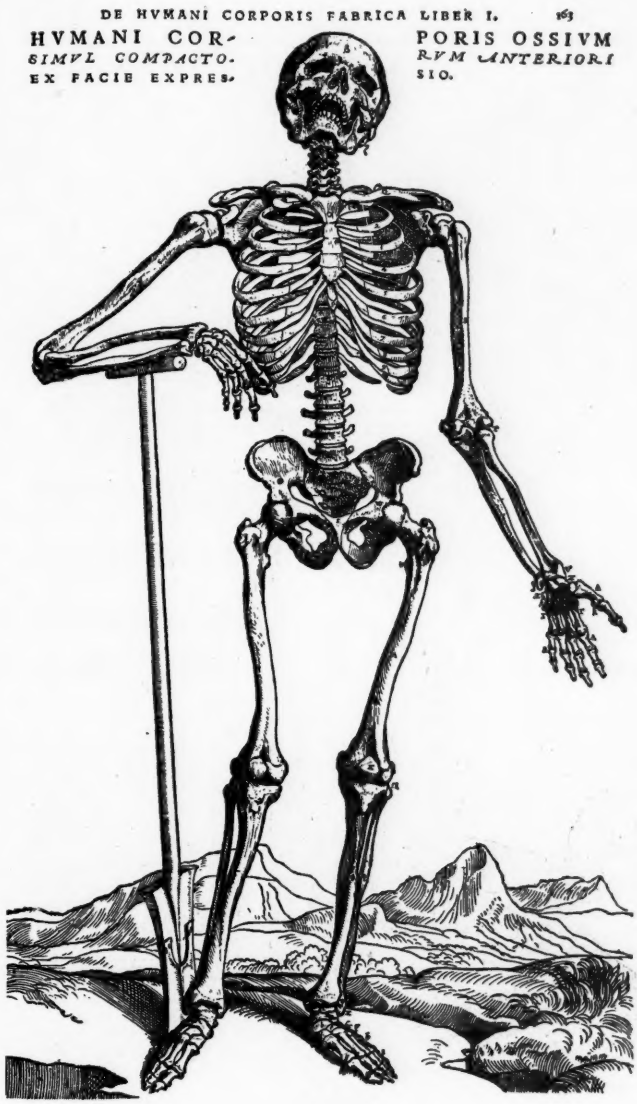


FIG. 313.

The muscle Tabulæ (*Figs.* 306–312) fall into two series: the one exhibiting muscles from the front, the other from the side and back. In the *Fabrica* the muscles are drawn, dissected in four layers from the surface inwards to the skeleton, the same on the two sides. In the *Epitome*, for economy's sake, the right half exhibits the more superficial layer of muscles, the left half the layer of muscles exposed when those seen on the right side have been cut away. The result as regards both the *Fabrica* and the *Epitome* is that every muscle comes to be depicted several times; each muscle is drawn, not only in position, but also raised from its origin, by which plan the belly of the muscle is exhibited, contracted as when in action, hanging dependent from its tendon of insertion.

If the figures are submitted to a close examination, there is disclosed remarkable evidence of ingenuity in designing the position of the general figures in conformity with the text. Taking them generally, the figures are free from animal anatomy. But Vesalius, both in the text, and by repetition in the indexes of the illustrations, laid emphasis on corrections he made to Galen's descriptions. Instead of describing the separate flexor and extensor muscles of the thumb and great toe, Galen had noted merely slips from the tendons common to the fingers and small toes. The description of the plantaris and of its insertion into the

os calcis to the inner side of the tendo Achillis corrected Galen's statement, derived from the monkey, that the tendon of the plantaris was continued into the plantar fascia. Galen had described the popliteus muscle of the monkey as the chief flexor of the leg upon the knee, whereas Vesalius showed it to be in man a small and relatively unimportant muscle.

In two instances in particular, however, Vesalius introduced confusion, which separate figures would have avoided. In order to illustrate Galen's description of the scalene and the rectus abdominis in the dog and monkey respectively, he added to the human muscle a drawing of the extension of this muscle in animals. Whilst in other figures the human rectus abdominis is depicted, in the 5th muscle *Tabula* (*Fig.* 308) of the *Fabrica* there is drawn a continuation of the muscle upwards over the front of the ribs, as far up as the first rib ; special lettering and a dividing line mark this extension of the rectus abdominis found in long-tailed monkeys.

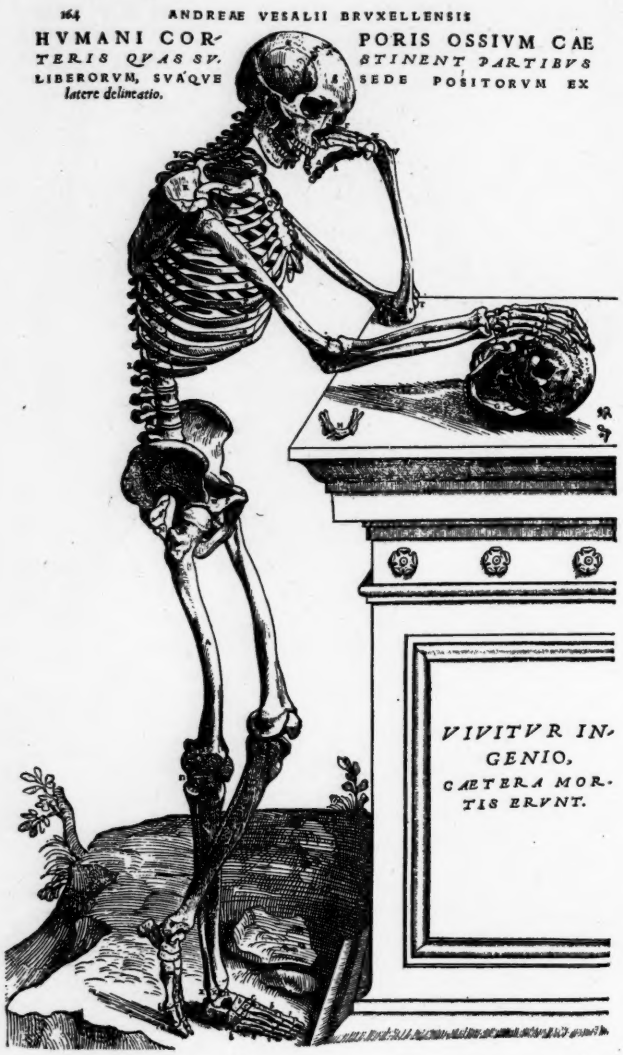


FIG. 314.

In several figures the human scalene, triangular in shape, is treated as an undivided muscle. In the 6th muscle *Tabula* (*Fig.* 309), in order to illustrate Galen's description drawn from the dog, the muscle is shown continued as a strip over the front of the ribs, anterior to the serratus magnus, the extension being likewise distinguished by special lettering and lines.

The following are noteworthy instances of detail in the drawings : in the 5th muscle *Tabula* (*Fig.* 308) the pyramidales are distinguished from the recti abdominis muscles ; by examining the series in which the external and internal oblique and the transversalis abdominis muscles are portrayed, the course of the spermatic cord through the internal and external ring is demonstrated. In the 7th muscle *Tabula* (*Fig.* 310) the under surface of the diaphragm is in view, whilst in a separate figure the detached diaphragm is exhibited with its crura, central tendon, and peripheral muscle. Vesalius, who was fertile in his comparisons, likened the shape of the detached diaphragm to a sting ray, but added that it was not a very good comparison. He held that Galen had described the œsophagus as passing behind, whereas he drew the opening for the passage through the diaphragm of the œsophagus on the left, and that for the vena cava on the right.

The representation of the muscles from the side (*Fig.* 307) and back (*Fig.* 311) show the superficial muscles in action, and are valuable illustrations from the artistic point of view. The deeper layers of the muscles (*Fig.* 312) were of importance, said Vesalius, because it was by them that man gained a superiority over animals as regards the mobility of the spine, and the free movements of the shoulders, hip, and other joints. In animals the spine was rigid, and the shoulder and hip movements were limited to one movement backwards and forwards.

The three *skeleton figures* at the end of the first book of the *Fabrica* were drawn from the articulated skeleton of a young man, age 18, so that the epiphyseal lines are shown, the same skeleton being drawn in a different position from three distinct points of view. Apparently it was the same skeleton as that represented in the *Tabulæ Anatomicæ*; if so, defects in earlier drawings were improved upon in those included in the *Fabrica*. The skull had been drawn too flask-shaped, the pelvis too horizontal and quadrangular, the neck of the femur too horizontal, the upper limb, arm, forearm, and hand over-long, so that the tip of the middle finger reached far below the middle of the thigh, and the wrist-joint much below the great trochanter, the femur too long for the tibia, the patella overlapping the head of the tibia. In the *Fabrica* the lengths of the humerus and ulna, of the femur and tibia, agree fairly well with the data in present-day anatomical works, the pelvis is tilted forwards, the neck of the femur set at an obtuse angle to the shaft, the patella placed between the condyles of the femur. Even so, Vesalius himself criticized some figures, saying that the thorax had been articulated so as to make it too barrel-shaped, the upper edge of the ribs had not been turned inwards enough, and the distance between the lower ribs and iliac crest was exaggerated, apparently owing to the excessive thickness of the pads which represent the intervertebral discs. Indeed, his figures of the thorax drawn later show a remedying of these defects.

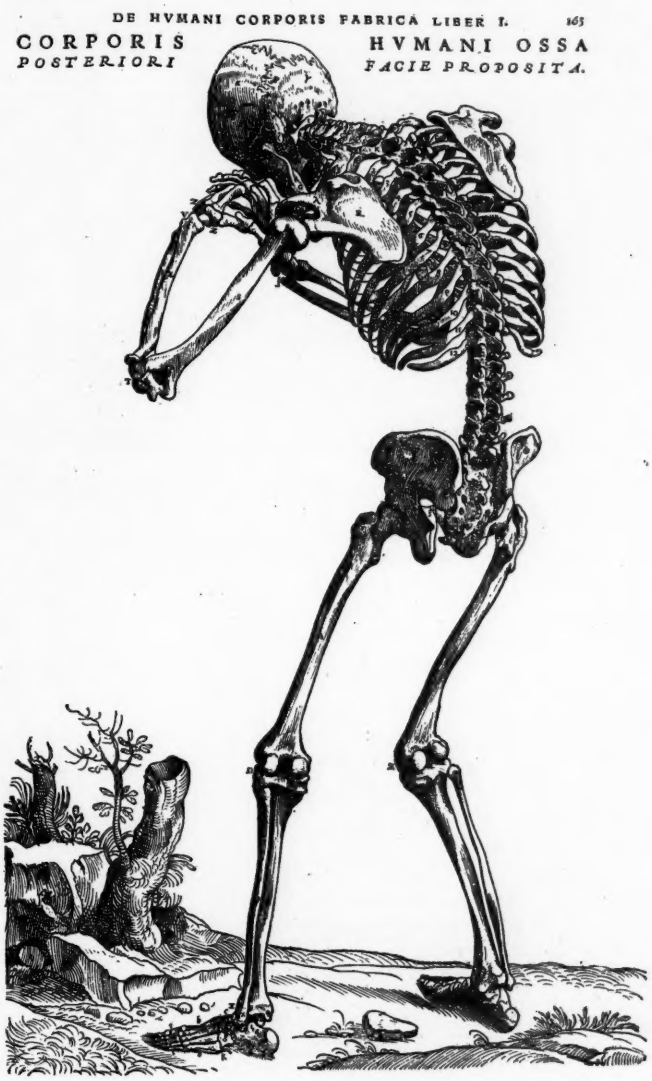


FIG. 315.

The first skeleton figure (*Fig.* 313), with the right elbow resting on the gravedigger's shovel, exhibits the epiphyseal lines of the acromion, head of the humerus, lower end of the radius, lower end of the femur, and upper and lower ends of the tibia. Among other details there is drawn the radio-ulnar triangular cartilage; elsewhere Vesalius

VENARVM, ARTERIARVM, NERVORVMQVE OMNIVM INTEGRA DELINEATIO,
BIMVL CVM NVTRITIONIS QVAE CIBO POTVQVE FIT ORGANORVM; ET CORDIS PVLMONISQVE
ac demum muliebrium generationi subseruientium instrumento- rum imaginibus.

FIGVRAE HVIC CHARTAE IMPRESSAE, cuiq; alia agglutinatur, ac quae peculiariter neruis ostendendis parata est, characterum Index.

CEREBRVM una cum cerebello cerebriq; cerebrum in medium hic dehiscentem, quali è cadauere eruditum in ipsius habitu conspicerent, ut ad ea, quae ex eius cruditate caput in posterum quam maxime fleberet, sursum retrosumq; oculi effertur. Caterùm quoniam uarijs latera tabulis ignorantem in praesentiarum fugauerit, sufficeret unu tantùm latere characteres adhibere.

A,B,C Cerebr ex alterolatere basis ut uatur, ac A indicat partem ipsius ad rectā sinum prominentem, nonnullis; mamillarem processum nuncupatam. B uerò cerebri parietem denotat, amplam caluariae sinum subeuntem, qui ad latus sinus confistit, quo glans cerebri, postquam excipiens reprimitur. C autem maximè posticam cerebri sedem notat.

D,D Cerebellum.
E Sinister cerebri processus, organo olfactus subseruiens.
F Nerus sorij seu Auditorius.
G Neruorum uisoriorum coitus.
H Tunica, in quam ex sorijs neruis euoluitur, degeneratio.
I Secundum neruorum cerebri par.
K,K Maior radix tertij paris.
L Crassior radix tertij paris.
M Quartum par.
N Quinti paris gracilior radix.
O Quinti paris insignior radix.
P Trochlea, in quam quintum par in oculos organo praecipuè exeuit.
Q,R Maioris quinti paris oculeus propagines, quorum hic pars cum alijs suo seminat, illa uerò per alium sibi proprium.
S Sextum neruorum par.
T Septimum neruorum cerebri par. ex horum neruorū progressu hoc unu del neuri possunt, quamuis inter se magna ex parte in aliis huius compendij figuris passim, praecipuè uerò in hac superposita, ex sortia ad musculos oculorum praecipuè paratarij occurrant.
V Dorsalis medullae ex cerebri basis medio in tuum.
O Dorsalis medulla se fedes quas celeberrimi egregij uer.
o,o,o Numeri characteres septem cernicis, duodecim thoracis, quinq; lumborum, & sex sacri ossis indicias uertebras, ex quibus reginas neruorum a dorsali medulla profluentium paria, quorum seorsum quaeq; suos accuratissimè & simplicissimè in hac tabella monstrare delineata expressi. Verùm quia hic locus exiguum cherubi rum declarationem admittit, non omnes neruorum soboles hactenus insigniuerim sunt.
P Septimi transuersi sinistri nerui, quem circa alam cherubicam operam ex quare, quinq; & sexti parium propaginibus effornari conspicis, prompcum enim est dei uentionem intelligere, si prius descripta neruorum series hic pictura accommodetur.
Q Neruus è quinto pari cui summum humerum inuestiunt, & dein musculo brachium mouenti praecipuè distribuitur.
R Primus brachij neruus, ossiculq; propagines hic in cutē excurrentes.
S Secundus brachij neruus, ossiculq; in anteriorem cubitum flectentium musculum sobolet.
T Tertius brachij neruus, ossiculq; propago cui anteriorem brachij sedem naturaq; obtulit.
V Tertij neruj propago ad musculum posteriorē cubitū flectentem.
X Secundi neruj portio tertium accedens.
Y Ramus secundi capitis adiens longi oris radium in pronum neuratis musculi.
Z Secundi distribuitur in duos imparesq; ramos.
a Minor ramus secundum radium cuti ad pollicē usq; exporrectus.
b Crassior ramus mox in duas propagines diuisus, quarum fibres in conflictus est.
c Tertij neruj soboles in musculos internum cubiti sedem occupantes digestae.
d Tertij neruus radio exporrectus, ac dein pollici & indici & medio furculos offerens.
e,e Quartus brachij neruus, atq; inferius e ramos mittit musculis cubitum extendentibus deprompcos.
f Quarti ramus internum brachij cuiem adens.
g Quarti ramus externum & posteriorem brachij accidens cuiem.
h,h Quarti ramus cubiti digestus.
i Quarti praecipua & Articulo ad ingressum cubiti.
k,k Quarti ramus radio exporrectus, & externae fedi pollicis, indicis, & medij soboles offerens.
l,l Quarti ramus ulnae exporrectus, & musculis ab externa ipsius facie in tram ducendis tendinibus exhibens, ac anae brachiale effans.
m Quartus brachij nerus.
n Quinti nerui feries in musculos ab interno brachij ossa tudem promanans.
o,o Quinti nerui ramus ulnae exporrectus, & internae fedi parui digiti & anularis, aliquando & medij musculos dispergens.
p Dicti medij rami soboles in externum manus sedem reflexae, ac externae parui digiti fedi & anularis & medij furculos dispensans.
[-] Sextum brachij nerum, ossiculq; sub cute tenuis ductu feries. Quinti uerò brachij neruorum fit excursus, principiorum quae plexum, ossa manus prompte dignoscitur.
r,r,r Nerui sunt intercostales, illic pressis, quā cum costis extrorsum reflectuntur.
s,s Rami in posteriora thoracis, hic ut in medio obuij.
t,t Hi musculi feriè nerui musculos adiens thoracis ossibus insituos.
u,u Propagines indicantur, sexti paris neruorum cerebri ramum costarum uel costas exporrectum augentes.
v,v Propagines neruorum ex lumborum uertebris exeuntium, quae ad omnes & huius fedis musculos & cuti dispensantur.
x Neruulus tertium frequenter parum, hicq; reflectus.
y Propagines sextum pinnarum alarumq; musculum.
z Tertius finus pectoris neruus.

a Primi neruj propago cuti obiecta.
β Primi neruj propago alterius inter musculos assumpta.
γ Secundus femur petens neruus.
δ,δ Secundi neruj soboles per internam femoris regionem sedem ad pedis usq; superiora sub cute excurrens.
ε Secundi neruj propago musculis anteriorem femoris sedem occupantibus deprompta.
ζ Tertius femoris neruus.
η Tertij propago, internam femoris cuiem ingredians.
θ Tertij propago musculos adens.
ι,ι Quartus femoris neruus, cuius exortus aequè atq; trium superiorum est conspicuus.
κ,κ Serius anteriorum propaginum inferiorum partium è sacro osse prodeuntium.
λ Dorsalis medullae extremum.
ρ Quarti femur petentis neruj propagines ad capita musculorum à coxendicis ossis appendice prodeuntium sparsae.
σ Quarti neruj soboles in posteriorē femoris cuiē ad medium usq; longitudinis femoris excurrēs.
τ Propago praecipua in quare in i huic musculum musculum, ac dein in reliquam posteriorem femoris cuiem ingressa genu & gressu.
υ Soboles in musculos ab inferioribus femoris capitibus pronatos.
φ,φ Quarti neruj in duos truncos distributio ac unus quidem minorem, q uerò insignioremneras.
χ Minoris trunci propago, externae ubiq; cuti ad pedis digiti usq; extremum diffusae.
ψ Propago subcutē inter musculos exporrecta.
ω Ramulus anteriorem tibiae cuiem implicans.
ϙ,ϙ Grandioris trunci ramus internae cruris hinc ad pollicem usque digestus.
ϡ Grandioris trunci ramus, posteriori tibiae fossae cuti exporrectus.
ϟ Grandioris trunci ramus, hgenerali penetrāti fibulam tibiae quā hae ossa inuicē deh scunt cōmixtus, ac dein ad digitorum usque superiora excurrens.
ϻ Praecipua grādioris trunci portio, inter tibiae & talum pedis inferiora petens, singulis digitis furculos offerens.

FINIS.

Prima columna in E, uersu 17. lege, promit 1 col. F, uersu 9. glandula nucis pinew instar effigiata 2 col. in G, uersu 9. perficiuntur.

SERIES CHARTARVM.

A B C D E F G H I K L M, praeter duas chartas nullo charactere insignitas: è quarum una figuram parare licebit, figuraeq; in pagina secunda folij & depictae agglutinandā. ex altera uerò, figura parabitur, ad figuram quae huic paginae impressa est, figenda. Reliqua uerò duodecim folia ex cuiusque arbitratu sunt inuicem nectenda: quāuis magis conueniat A cum M, & B cum L, & C cum K, & ita deinceps iungere, ut uniuersa Epitome quodammodo sexternionē constituat, modò in libri formam haec concinnare lubeat.

BASILEAE, EX OFFICINA
Ioannis Oporini, Anno MDXLIII.
Mense Iunio.

M

FIG. 316.—A page of the *Epitome*.

CHARTA, EX QVA FIGVRAM PARARE CONVENIT, ILLI QVAE NERVORVM SERIEM EXPRIMIT APPENDENDUM

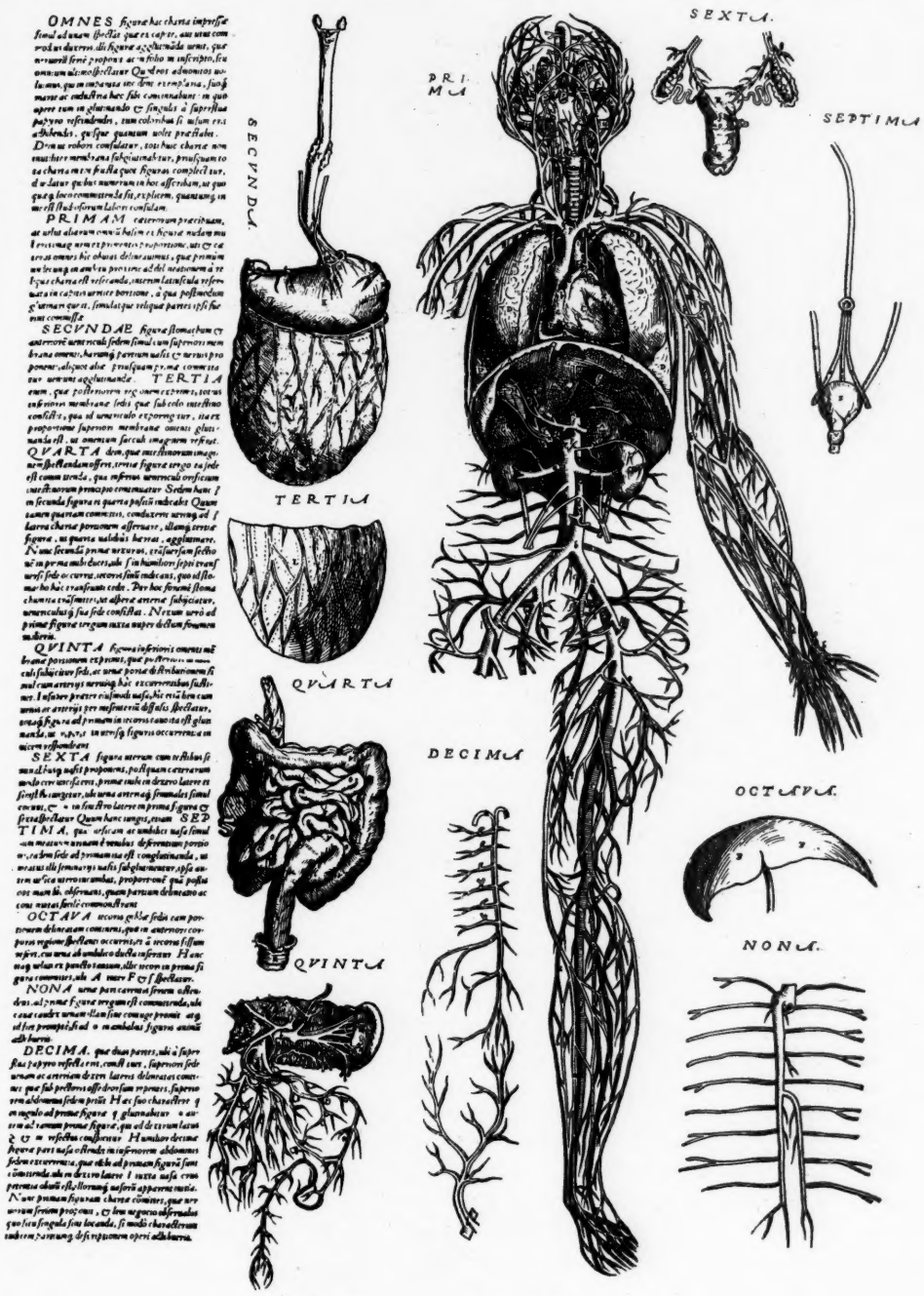


FIG. 317.—A page of the *Epitomee*.

described and drew the interarticular cartilages of the knee, of the temporomandibular joint, and of those at each end of the clavicle. The sesamoid bones are shown, included with them being the pisiform bone, and the os vesalianum separated from the projection at the base of the fifth metatarsal.

The second skeleton figure (*Fig.* 314), leaning on a monument, has supplementary figures in order to show the under surface of the skull, the hyoid bone, and the malleus and incus, lying on the top of the monument. This was the figure repeated in the *Epitome*, because such is the position of the skeleton that practically all the bones and joints are exhibited, and that on both aspects front and back, with one or two exceptions: the sacrum and coccyx and the lesser trochanter of the femur cannot be seen.

The epitaph on the monument has for its aim the countering of the objection to the examination of the body after death: *Vivitur ingenio, cætera mortis erunt* ('Man's spirit lives: all else death's hand shall claim'. *English by Miss Joyce Lowe, M.A.*).

The third skeleton figure (*Fig.* 315) is drawn from a standpoint half-way behind and to the left, in a position in which the spine is bowed forwards with the forehead resting on the clasped hands. Thus the skull, spine, scapulæ, and shoulder-joints are viewed from a peculiar position. By close examination of the three figures the complicated intercalation in the several designs can be appreciated; thus the shoulder and hip-joint, the upper and lower limbs, are portrayed each in half a dozen different ways, varying with the several positions. On the other hand, each of the three figures supplies some representation not in the others. In the third figure the sacrum and coccyx are shown in their human curve without any suggestion of a tail; the sacrum is represented as formed by six bones, because, so Vesalius said, that was the case in the particular skeleton drawn.

Now supposing we direct our attention to movements with which we are familiar, such as overhand bowling at cricket or serving at tennis, in which the arms have the major rôle; or to those in running and jumping, in which the legs play the chief part, but in which the simultaneous movements of the arms are of importance; or, thirdly, to rhythmic movements such as the performance on the stage of the dance of the Greek warrior—all of which complicated motions may now be viewed by means of photography on the moving films, and the movement of joints through an *x*-ray screen: it is remarkable evidence of the genius of Vesalius that his muscle and skeleton figures may be used in the analysis of these and other complicated movements.[2]

Horizontal Sections through the Brain.—The illustrations of the human brain in the *Fabrica* are noteworthy, because on examination it becomes obvious that the drawings were made directly from the anatomical preparations. Not only are there drawn parts which are named, but there are outlines which, although unnamed, can be recognized as representing structures which the draughtsman had under his eye.

Figure 4, page 608, is a drawing of a horizontal section through a man's brain which had been made at the level of the corpus callosum. The part of the left hemisphere thus cut off was turned over so that in a separate figure the roof of the lateral ventricle formed by the lateral expansion of the corpus callosum could be depicted. At the margins of the hemispheres the outlines of the convolutions and sulci are marked, that external to the undulating lines being stated to be yellowish or greyish owing to the supply of blood through the vessels of the pia mater, and that internal to the waving line white, dotted with red points. In front and behind the lateral ventricles and between the hemispheres lay the corpus callosum, distinguishable from the rest of the brain. Between the ventricles the hinder limb of the fornix is drawn, although not named in this figure. The floor of the lateral ventricle on each side exhibits outlines of the nucleus caudatus of the corpus striatum, and also of the optic thalamus; overlying this is seen the choroid plexus receiving cobweb-like veins and turning down into the descending horn. The tænia thalami and the stria medullaris are drawn, but not named.

Figure 5, page 609, the next figure, represents a horizontal section immediately under the previous one. The corpus callosum is drawn after being divided in front at its genu,

raised and turned back, so that its posterior limbs, coming up from the descending horns, are seen to unite to form the body. The tapering off in front shows the junction of the body with the anterior limbs. A ridge along the under surface of the corpus callosum corresponds with a groove on the dorsum of the fornix. This marks the septum lucidum, which Vesalius said could be best demonstrated by looking at it sideways whilst the corpus callosum was held up with the fingers of the two hands. To give one instance of his fertility in comparison, he said it resembled a precious stone ground thin, a sheet of mica set in a window or door, or the wafer used at Mass.

Figure 6, page 610, shows the fornix raised and turned back from the front, thus exposing the meeting of the choroid plexus of each side, which then was reflected as the tela choroidea or velum interpositum, to become continuous with the vena magna Galeni, and through that with the straight sinus and the torcular Herophili. The choroid artery from the internal carotid is shown entering the extremity of each descending horn to join the end of the choroid plexus. A groove between the two optic thalami, forming the middle line of the third ventricle, leads forwards to the infundibulum and backwards to the aqueductus Sylvii.

Figure 7, page 611, depicts a horizontal section below the floor of the lateral ventricles. There is thus shown in horizontal section the optic thalamus, the nucleus caudatus, the nucleus lenticularis, and—between them—the internal capsule. Outside the nuclei is drawn the external capsule, and further out still an outline of the island of Reil.

This and the following figure afford a peculiar proof that the artist had before him the anatomical preparation, and drew what he saw. On the right there are lines indicating the division of the lenticular nucleus into the putamen and the globus pallidus; on the left the horizontal section has dipped a little lower, so that there appear lines indicating commissural fibres between the globus pallidus and the optic thalamus, although no name is given to these lines.

Figure 8, page 613, also shows the left side cut a little lower than the right, which not only confirms the above, but affords the additional evidence that the sections were made in series from the same brain.

The Nerve and Vein and Artery Diagrams.—The diagrams which Vesalius inserted in the *Fabrica* and *Epitome* should be considered after taking due note of the explanations concerning them included in the text. Critics have merely glanced at them in a superficial way, and condemned them as rough, untrue, or antiquated. The nerve diagram (*Fig.* 316) was drawn for the *Epitome*, indeed it may have formed the last drawing for the *Tabulæ Anatomicæ* which is missing from the Collections reproduced by Stirling Maxwell and by Holl and Sudhoff. Being drawn for the *Epitome* and so of greater length, when bound up in the *Fabrica* the lower fourth had to be infolded. Explanations concerning this diagram are given (*Fabrica*, 1543, iv, pp. 353, 354; p. 338, *86, i, line 14*; and 1555, iv, 532, *87, 1*). The same remarks apply to the combined vein and artery diagram (*Fig.* 317) (*Fabrica*, 1543, iii, p. 313).

These diagrams occupy the full length of the pages of the *Epitome*, where it is stated that for elementary instruction they were intended to be cut out and then applied over the female nude and other full-length figures.

The Museum of the Royal College of Surgeons possesses the *Tabulæ Evelianæ*, the origin of which was described by Evelyn in his *Diary*. On comparison with the nerve and the combined vein and artery diagrams in the *Fabrica* and *Epitome*, the relationship of the latter with the *Tabulæ Evelianæ* becomes apparent. Before the introduction of methods for preserving anatomical material from putrefaction, and for the injecting of blood-vessels, nerves and blood-vessels were rapidly dissected out and then spread on boards for inspection and drawing; after being varnished over they could be preserved. Evelyn's account shows that, a century after Vesalius, his successor in the Chair of Anatomy at Padua, Vesling, supervised the preparation for Evelyn of human nerves and blood-vessels by the same method as had been adopted by Vesalius when preparing his diagrams.

The examples I have referred to explain why the illustrations designed by Vesalius form an important foundation upon which the present knowledge of human anatomy is grounded. But the general impression gained by a study of the writings of Vesalius leads further to the conclusion that he had a wider aim than that of instructing students of medicine and of art. He would have an educated man possess a knowledge of anatomy and physiology, and there was a tendency in this direction during the 16th and 17th centuries. Christopher Wren and Evelyn may be cited as studying anatomy seriously, although perchance others, like Pepys, may have gone to an Anatomy at Barbers' Hall out of curiosity.

To-day, outside the wide boundaries of medicine and of art, few can be said to follow the exhortation implied in the letter by Vesalius dedicating the *Epitome* to Prince Philip :—

"You will think it base and unworthy that, while such varied courses of study are pursued, the composition of the body which accompanies us through life should be a secret from us ; that man should be absolutely unknown to himself ; and that we do not examine the construction of the organs formed so perfectly by the Almighty Designer of the Universe. The vital activities of these organs by which everything is accomplished we confine ourselves merely to wondering at."

I conclude with the following epigram by Vesalius :—

I am good health, put to the test and tried ;
Unhappy mortals I am here to guide,
Unless indeed I'm snatched off by some blow,
Or play the run-away before some foe.
At first, in very truth, a tempest black
Of jealousy and envy held me back,
For few essays there are, so I have heard,
That fear of envy hath not first deterred.
But yet at last, despite Sir Envy's sway,
Despite all jealousy, I broke away,
I burst my bonds, to none would I be thrall :
My name is known : I shall be read by all.
Do only thou, dear Reader, take in hand
This fruitful work, and spread it through the land ;
With cheerful brow assist me in my task,
And make the dutiful attempt I ask.
Foster the strength that grows, nor treat with scorn
The strength that deep within the soul is born,
For 'tis that strength which in the after days
Shall bring forth fruit from slight and scant essays.

(English renderings by Miss Joyce Lowe, M.A.)

The illustrations reproduced in this paper are from photographs of wood-block engravings in the *Fabrica*, 1543, and from the copy of the *Epitome* printed on vellum in the British Museum Library.

NOTES.

[1] p. 394.—The *Fabrica* was subjected to indiscriminate plagiarism (L. *plagiarius*, a kidnapper). The woodcut 303, p. 385, illustrating the apparatus used by Vesalius in dissecting, with the addition of a bleeding bowl and centrebit, appears in *Clowes On Gunshot Wounds*, 1637, Cap. 27, to illustrate " a note of certain necessary medicines and instruments good for young practisers of surgery ", and this in turn was copied by Gurlt as " a woodcut of Clowes showing his surgical instruments " (Gurlt, *Geschichte der Chirurgie*, 1898, iii, 365).

[2] p. 400.—The drawings of an articulated skeleton from four points of view preserved in the Uffizi Gallery, Florence, and attributed to Leonardo da Vinci, were made whilst the skeleton was hanging loosely from a peg. (*See* Holl u. Sudhoff, *Archiv. für Geschichte der Medizin*, 1914, vii, 334, Tafel viii.)

THE EFFECT OF GASTRO-ENTEROSTOMY ON GASTRIC FUNCTION, AS INTERPRETED BY THE FRACTIONAL TEST MEAL.

By ERNEST F. GUY, Manchester.

The method of investigation of the functions of the stomach by the fractional test meal, as introduced by Rehfuss,[1] has hitherto been applied chiefly as an aid to diagnosis. The present investigation represents an effort to study the effect on the gastric functions of the operative measures adopted in the treatment of chronic ulceration of the stomach and duodenum, and to account for the varying results obtained.

The old method of withdrawal of a single specimen one hour after a test meal is unsatisfactory, since it demonstrates but one phase in a constantly varying cycle. By employing the fractional test meal, the state of secretion and motility of the stomach can be followed throughout the course of digestion.

Patterson,[2] basing his views on the results obtained with the old type of test meal, found an average reduction of 30 per cent in the gastric acidity after gastro-enterostomy, and a slight acceleration or retardation of the rate of emptying, within physiological limits. On these assumptions he attributed the beneficial effects of the operation to the diminution of hyperacidity, and not to improved drainage.

The application of the fractional test meal to the problem does not appear to have received attention by many observers.

Bonar[3] stated that the post-operative acid level varied with the position of the ulcer ; whilst Wilensky[4] did not find any relation between the position of the ulcer and the character or intensity of the changes. In a recent paper[5] the later writer appears to attribute the variations after operation to differences in operative technique.

Material employed in the Investigation.—Over 50 cases have been examined, and, of these, the presence of an ulcer has been confirmed at operation in 31. These have been provisionally classified, according to their position, as gastric, pyloric, and duodenal, and were distributed as follows :—

Gastric ulcer	..	3 cases
Pyloric „	..	9 „
Duodenal „	..	14 „

In 5 cases, whilst it is known that an ulcer was found at operation, no information has been obtained as to its exact position.

Twenty-six patients have been examined after gastro-enterostomy, and in 14 of these the curves before and after operation have been obtained. The remaining cases consist of patients presenting chronic abdominal symptoms due to causes other than ulceration. In many of these the absence of an ulcer and the presence of some other disease was demonstrated by laparotomy. The majority of the patients were pensioners receiving treatment at the Ministry of Pensions Hospital, Grangethorpe, Manchester.

Technique.—The usual method of withdrawal, by a Ryle's tube and syringe, of specimens of the gastric contents at 15-minute intervals after the swallowing of a pint of oatmeal, has been employed. Certain points have been developed in the technique of the examination which are believed to have important effects on the resultant curve.

The quantity withdrawn each time is limited to 2 c.c. To obtain a larger quantity often necessitates a pressure in the syringe sufficient to cause minute hæmorrhages from the gastric mucosa. Whenever blood has been found in the specimens of the present series of test meals, subsequent laparotomy has invariably proved its source to be an active ulcer.

The examination is continued until sixteen specimens have been taken, i.e., three and three-quarter hours after the test meal, in order to obtain a record of the 'after-secretion'. If large quantities of mixed food and secretion are removed, the test is often brought to an end too early by the complete emptying of the stomach.

A still more important modification is the early filtration of the gastric contents. As the specimen is withdrawn the syringe is emptied immediately on filter paper. This precaution obviates the marked changes in acidity which take place *in vitro* within the course of a few hours. A number of control titrations have now been made, from which the two following examples are taken. 'A' represents the titration figures of the specimen filtered immediately, 'B' those from the control specimen filtered after standing in the test tube for four to six hours at room temperature.

		Free HCl.	*Total Acidity.*
Example 1.	A.	7	16
	B.	0	11
,, 2.	A.	15	25
	B.	7	17

The amount of difference in acidity due to chemical changes proceeding *in vitro* depends on the stage of digestion at which the specimen is taken ; the greatest variations being noted when food is present. This variation is particularly marked after gastro-enterostomy, and may then result in a total disappearance of free HCl ; probably accounting for many of the anacid and subacid results claimed after this operation.

The titration is performed with a burette of small calibre with $\frac{1}{100}$-c.c. graduations, and fitted with a capillary dropper. By using this method accurate titrations can be made with 1 c.c. of filtered juice, or even with less on the rare occasions when this quantity is not obtainable. The first specimen is taken before the oatmeal is given, and in the more recent test meals the stomach has been completely emptied at this time in order to measure the quantity of resting juice. The disappearance of starch from the stomach is taken as the simplest means of indicating the final passage of food from that organ.

Bolton and Goodheart[6] have demonstrated the lowering of the acid curve caused by regurgitation through the pylorus of alkaline fluids even in the normal stomach ; but despite this, the height reached by the acid curve may be taken as a fair indication of the quantity of the total gastric secretion.

GENERAL RESULTS OF GASTRO-ENTEROSTOMY.

The motor and secretory functions of the stomach are profoundly modified by the existence of the new stoma, which permits a readier exit for the food and a freer entrance for the duodenal contents. The presence of the latter in the stomach is indicated by the appearance of bile in the specimens removed. The fractional test meal shows that bile is constantly present in the stomach after gastro-enterostomy. A very occasional single specimen is free from bile, but it is invariably present in the majority of specimens obtained during the course of the test. As bile is present it must be assumed that pancreatic juice has an equally free means of entrance, though its presence cannot be detected by any simple chemical test.

The freedom with which the duodenal contents now enter the stomach was well shown in one case in which *x*-ray examination after a bismuth meal proved that all the food was passing through the pylorus and none through the stoma, although the latter was found to be patent and of sufficient size when the abdomen was opened at a later date. Despite the fact that the stoma was apparently functionless as regards food, bile was present in every specimen of gastric contents examined.

The quantity of resting juice found in the stomach after gastro-enterostomy is extremely variable, more so than is the case before operation. Quantities varying from 5 c.c. to 150 c.c. have been recorded. This degree of variation is probably due to the freer communication with the jejunum which now exists, and in the present series the

quantity has appeared to bear no relation to the position of the ulcer. A possible fallacy in this estimation is the passage of the end of the tube through the stoma, though every effort is made to avoid this by keeping the measured mark on the tube opposite the incisor teeth when the specimen is taken.

On the motor side, so long as the stoma is functioning, the rate of emptying is always considerably more rapid than normal.

The gastric acidity is lowered by the influx of alkaline fluids. Pancreatic juice is the chief neutralizing factor, since it possesses ten times the alkalinity of any of the other fluids concerned. It is conceivable that the amount of alkaline fluid entering the stomach through the stoma would, at times, be sufficient completely to overcome the acidity of the gastric contents and to render them alkaline, but this has never been found to obtain after gastro-enterostomy. In this respect the following case is instructive.

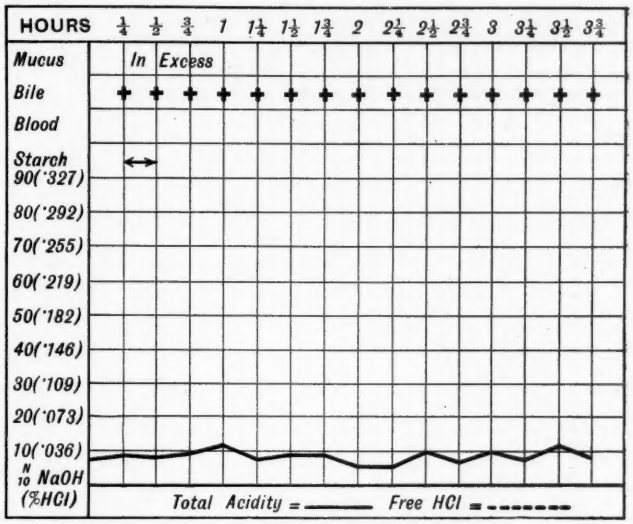


FIG. 318.—*Chart I.* Case of achlorhydria in which gastro-enterostomy had been performed.

Case.—J. S., age 34, was admitted to hospital with a history of gastro-enterostomy performed ten months previously for symptoms of abdominal pain and vomiting which had existed for two years. These symptoms recurred very shortly after operation. A fractional test meal on Nov. 26, 1921, showed a total absence of free acid and a very low total acidity, as can be seen in *Chart I* (*Fig.* 318). On Dec. 8, the abdomen was opened, and as no trace of an ulcer or of pyloric obstruction was found, the gastro-enterostomy stoma was excised and the normal continuity of the gut restored.

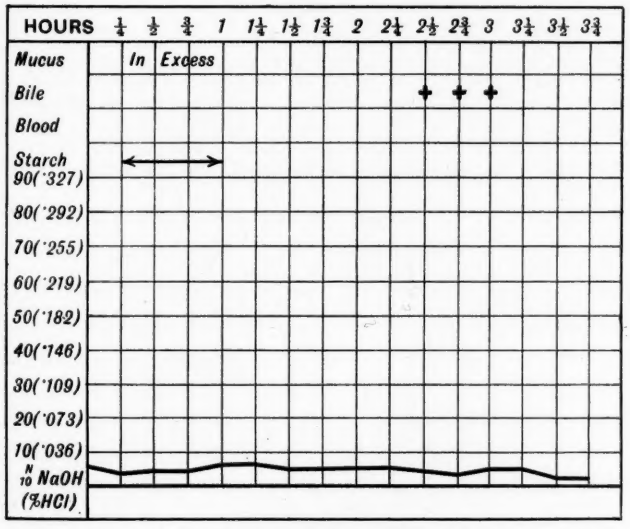


FIG. 319.—*Chart II.* Same case as in *Fig.* 318 after excision of the gastro-enterostomy stoma.

A fractional test meal taken one month after operation and repeated on Oct 31, 1922, gave the curve shown in *Chart II* (*Fig.* 319). The quantities of juice obtainable on each occasion were extremely small, and a condition of achlorhydria was still present. Examination of the digestive power of the juice demonstrated the presence of pepsin, which could be activated by the addition of HCl.

In this case, although the conditions present after the gastro-enterostomy were such as to favour the complete neutralization of the gastric contents, a low degree of acidity was still maintained.

The level to which the acidity of the stomach is reduced by gastro-enterostomy depends primarily on the position of the ulcer for which the operation was performed. It is therefore necessary to discuss the effects under different headings and to consider the altered state of the gastric functions previous to operation.

For purposes of comparison a normal curve will first be described.

The Normal Curve.—The normal curve given by Crohn and Reiss,[7] and largely adopted as a standard, is constructed from the average of a number of readings, and does not show features which are typical of an individual curve ; nor is it continued sufficiently long to show the after-secretion. Whilst it is realized that different apparently normal individuals show considerable variations in their curves, and that smaller variations may occur in the same individual at different times, the curve in *Chart III* (*Fig.* 320) shows most of the features which may be regarded as typical of a normally functioning stomach. It is owing to these variations that the actual shape of the curve is of but little importance, and attempts to classify curves on this basis can produce no useful results.

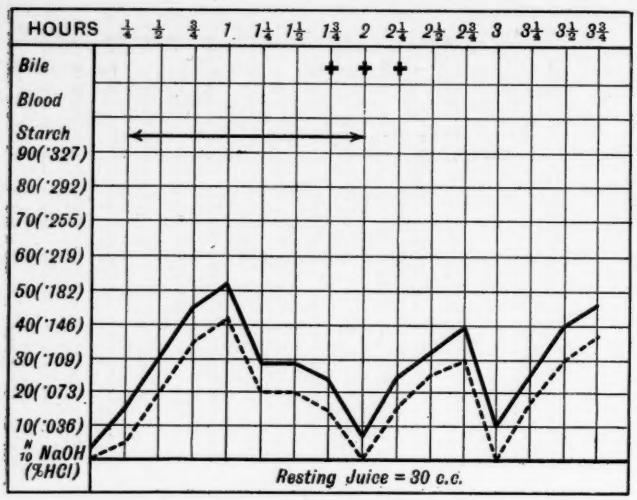


FIG. 320.—*Chart III.* A typical normal curve.

The following are the features of the normal curve.

1. *Motor Power.*—The gastric contents should be free from starch within two and a quarter hours. Longer periods than this are regarded as an indication of delay. Disappearance of starch within one and a half hours or less indicates 'hurry'.

The normal stomach always empties on a curve of falling acidity.

2. *Bile.*—This is constantly found in the stomach when the last portion of the food is passing out, and reappears at least once during the later stages of the test when the stomach is empty of food.

3. *Resting Juice.*—The quantity is variable. Fowler, Rehfuss and Hawk[8] examined over one hundred normal persons, and found an average of 52 c.c., with variations from 23 to 160 c.c. The total acidity of the normal resting juice is low, and should not rise above 20. Usually it is lower than this, and free acid is often absent. Bile is occasionally present.

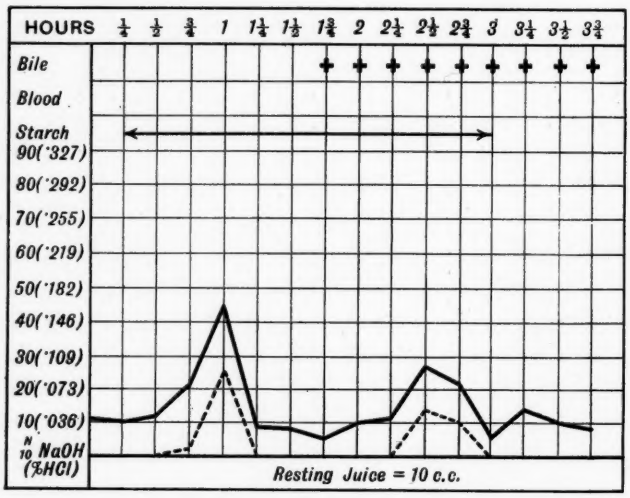


FIG. 321.—*Chart IV.* Gastric ulcer.

4. *Acidity.*—The acidity rises to a maximum in about one hour, the maximum being about 50 with an HCl reading of near 40. From this level the acidity falls as the stomach empties. After food has passed from the stomach the secondary rise (which may be single, or double as in the example shown) of the after-secretion occurs. The acidity of this secretion reaches a level as high as, or even higher than, that observed during the course of gastric digestion. It will be noticed

that the curve often finishes at a high level although the resting juice has a low acidity ; but it must be remembered that the latter is taken in the early morning twelve hours or more after a meal. In addition, the secretion of appetite juice in expectation of a meal at the end of the test probably plays a part in the formation of the terminal portion of the curve.

The variations in this normal picture which are induced by ulceration in the stomach and duodenum are as follows :—

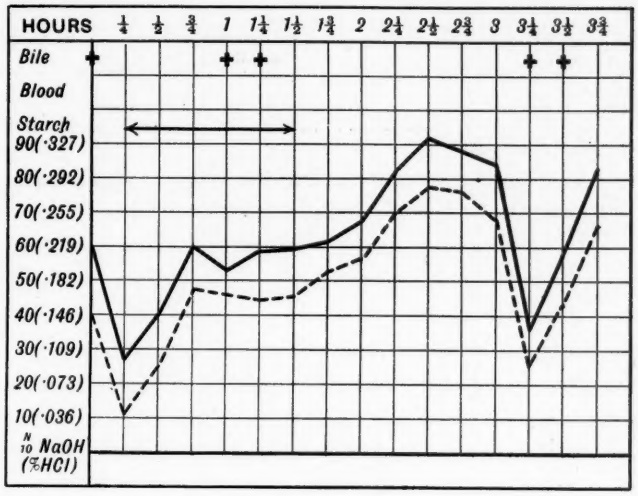


FIG. 322.—*Chart V.* Duodenal ulcer.

A. **Gastric Ulcer.**—Under this heading are included chronic ulcers occupying the body of the stomach. Three cases of this type have been examined, and show certain features in common. An example of the type of curve obtained by the fractional test meal in this condition is shown in *Chart IV* (*Fig.* 321).

1. *Motility.*—All test meals showed marked delay in the passage of food from the stomach, confirming the *x*-ray reports on these cases, which stated, "marked delay at the pylorus, probably due to reflex spasm". In one case, in which the stomach was greatly dilated and atonic, starch was present in the resting juice and remained throughout the test (three and three-quarter hours).

2. *Bile.*—Bile was present over much longer periods than is usual in the normal stomach, and in the case referred to above was found in every specimen.

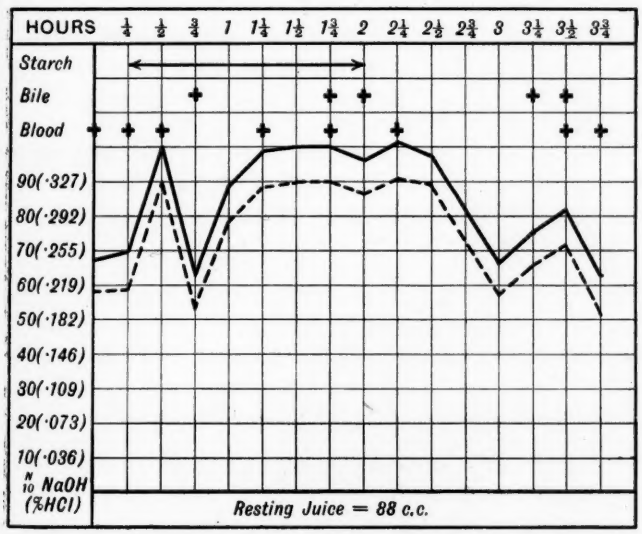


FIG. 323.—*Chart VI.* Duodenal ulcer with very high acidity and hæmorrhage.

3. *Secretion.* — Whilst no characteristic shape can be ascribed to the curve, its essential feature is subacidity, ulcers of the body being associated with hyposecretion.

As far as the secretory function is concerned, one would hesitate to make a diagnosis of gastric ulcer on the evidence of the fractional test meal alone. Although blood was not found in these specimens, its appearance in cases of active ulcer is to be expected, and would afford additional evidence for diagnosis. If the clinical history as regards pain, etc., leads one to suspect a gastric ulcer, a fractional test meal showing subacidity associated with delayed emptying is distinctly confirmatory.

B. **Duodenal Ulcer.**—The alterations in the gastric functions associated with chronic duodenal ulcers and as displayed in a fractional test-meal chart are very typical. *Charts V* and *VI* (*Figs.* 322, 323) show the curve in this condition.

1. *Motility.*—The earlier disappearance of starch from the gastric contents affords evidence of 'hurry' in the majority of cases. This has been noted even when *x*-ray examination has reported delay. Oatmeal provides a more natural food than the bismuth mixture necessary for *x*-ray examination, and therefore the fractional test meal gives us a more accurate picture of the gastric motility.

Examination of the ulcer at operation sometimes proved that either the ulcer itself or the surrounding fibrosis encroached upon the pyloric ring, and in these patients the rate of emptying was less rapid, approximating to, but never more delayed than, the normal.

2. *Bile.*—Occasionally present in the resting juice, bile enters at frequent intervals during the meal.

3. *Secretion.*—The resting juice, never less than 40 c.c. in amount, is highly acid. The average level in this series was 50, with a free acid reading 10 to 15 below. The acid curve is typically high, displaying as a rule a number of peaks. The curves of free acid and total acidity run parallel. The maintenence of a high level of acidity after the stomach has emptied itself of food should be noted. It is usually at this time that the highest degree of acidity is reached. This fact, combined with the high acidity of the resting juice, indicates a condition of continuous gastric hypersecretion associated with duodenal ulcer.

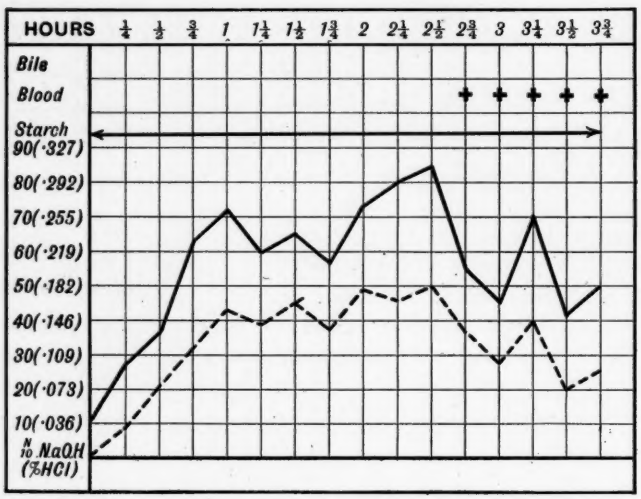


FIG. 324.—*Chart VII.* Pyloric ulcer.

C. **Pyloric Ulcer.**—In this class are placed all ulcers occurring in the pyloric portion of the stomach, including the pyloric canal and vestibule, as it has been found that the associated disturbance of gastric function gives rise to a fractional test-meal curve which enables these ulcers to be differentiated from those situated in the body of the stomach or in the duodenum. A typical curve is represented by *Chart VII* (*Fig.* 324).

1. *Motility.*—Delay in emptying is invariably found. This delay is often attributed in *x*-ray examination to obstruction at the pylorus, when operation shows that the pylorus is free. In these cases the cause is possibly a reflex spasm of the canal or pars pylorica similar to the hour-glass spasm seen in ulcers of the body of the stomach. This contraction is seen in the *x*-ray examination and taken for the pylorus, which is actually some distance away on the duodenal side. Reflex spasm of the pylorus itself may also account for the delay.

2. *Bile.*—A feature of ulcers in this situation is the comparative absence of bile from the stomach. When present it appears late in the meal.

3. *Secretion.*—The resting juice is of smaller quantity than is found in duodenal ulcer (unless a marked degree of pyloric stenosis be present), and, unlike the latter, shows an acidity well within the normal limits. From this low level the curve rises, and shows a considerable degree of hyperacidity, which is maintained for a time, but tends to fall before the end of the test. In some cases, as in the example shown, the HCl curve does not show the same tendency to run parallel with the curve of total acidity that is seen in other conditions. The retention of the products of gastric digestion allows a greater combination of protein and HCl to take place, thus relatively increasing the amount of total acidity. Two of the curves obtained were of the 'climbing type'

described by Bolton[9] as due to spasm of the pylorus. In view of the smaller quantity found of resting juice of low acidity, it must be assumed that hyper-secretion is not so marked a feature with pyloric as with duodenal ulcers, and the excessive secretion occurs as a reaction to a food stimulus rather than as a continued independent phenomenon.

Included in the group under consideration are ulcers situated actually at the pylorus. It is a matter of the greatest difficulty to declare definitely, at the time of operation, the exact source of these ulcers. One is faced with a scarred ulcer mass whose cicatrix and surrounding œdema have obliterated to a large extent the usual landmarks—the pyloric vein and the faint pale line that mark the pylorus in the normal stomach. There are only two possible sources of origin. Either the ulcer has occupied the duodenopyloric fornix[11] and grown into the sphincter, or it has begun in the termination of the pyloric canal itself. Whatever their origin, the fractional test meal shows that their secretory curve approximates more closely to the duodenal type in displaying a larger quantity of resting juice of high acidity ; but the associated motor signs are those of ulcers on the gastric side of the pylorus. The delay in these cases is due to cicatrization and œdema rather than to spasm.

Though certain degrees of hyperacidity may be found in conditions other than ulceration of the stomach and duodenum, the typical features of the curves described above have not been met with in such conditions. In three patients who gave curves of the type described, the scar of a healed ulcer was found producing no obstruction or deformity. It thus appears that the abnormal functional state of the stomach can persist after the healing of the ulcer.

With regard to the question as to whether hyperacidity is a cause of pain in ulceration, a study of the curves showed no constant relation between the times at which the gastric acidity reaches its highest levels and the time of onset of the pain, unless one can associate the onset of late pain in duodenal ulcer with the entrance into the duodenum of the highly acid after-secretion.

EFFECTS OF GASTRO-ENTEROSTOMY IN THE DIFFERENT TYPES OF ULCER.

After this preamble we may discuss in more detail the effects of gastro-enterostomy on the function of the stomach in the above-enumerated pathological conditions.

1. **Motor Effects.**—As already mentioned, the rate of emptying after a satisfactory gastro-enterostomy is always considerably more rapid than is found in the normal stomach. The average time taken by the stomach to empty itself of food under the new anatomical conditions is one and a quarter to one and a half hours, and this is irrespective of the position of the initial ulcer. With ulcers at or on the gastric side of the pylorus this means that the food leaves the stomach at a very much earlier time than was possible with the pre-operative delay. When the pylorus is free one would expect to find that the additional opening increased the speed of emptying, but this view does not take into account the effect of the chemistry of the stomach and duodenum in exercising a control over the movements of these organs. Thus, in duodenal ulcers associated with marked hurry before operation, a gastro-enterostomy lowers acidity and sometimes diminishes the rate of emptying, although this remains more rapid than in the normal unoperated stomach. Although the fractional test meal supplies no direct evidence on the question, the size of the stoma is probably not a matter of very vital importance, for we may assume that nowadays all surgeons make the gastro-enterostomy opening at least larger than the normal pyloric diameter.

Five test meals were carried out on patients in whom partial gastrectomy had been performed. They showed a still faster emptying than is seen after simple gastro-enterostomy. The average time was three-quarters of an hour. It is noteworthy that in several patients examined, whose symptoms of pain and vomiting had recurred after gastro-enterostomy, the stomach took two or more hours to empty. In one of these, at least, the stoma had ceased to function as an exit for food.

2. Effects on Gastric Acidity.—Assuming that similar anatomical conditions are present in all cases after gastro-enterostomy, the extent to which the gastric acidity is reduced must depend on the relative quantities of acid in the stomach and of alkali entering through the stoma. We have no reason to suppose that the latter varies with the position of the ulcer, but we have already seen that the quantity of acid secreted by the stomach does vary according as the ulcer is nearer the cardia or the duodenum.

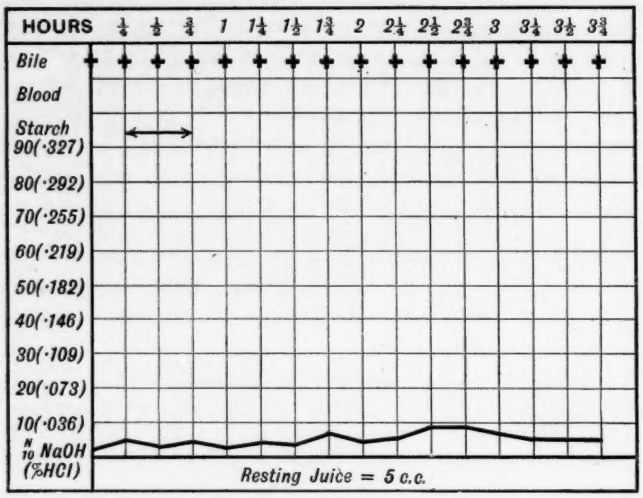


FIG. 325.—*Chart VIII.* Gastric ulcer after gastro-enterostomy. Pre-operation curve shown in *Chart IV* (*Fig.* 321).

The fractional test meal confirms what might be expected from the theoretical consideration of the effect of gastro-enterostomy in ulcers in these different situations. It may be stated at the outset that whether partial gastrectomy or gastro-enterostomy alone be performed, there appears to be no difference in effect on the resulting acidity, In the cases in which the former operation had been performed, the post-operative reduction in acidity was no different from what one would expect from gastro-enterostomy alone.

a. Gastric Ulcer.—The state of hyposecretion and hypo-acidity associated with ulcers of the body of the stomach favours a large reduction in the post-operative acidity. In all cases free acid entirely disappeared from the stomach, and the total acidity did not rise above 12. *Chart VIII* (*Fig.* 325) shows the post-operative curve of the case whose curve before operation is seen in *Chart IV* (*Fig.* 321).

b. Duodenal Ulcer. — Since duodenal ulcers are accompanied by such marked hypersecretion, a much smaller reduction in acidity after gastro-enterostomy is to be expected. It has been found invariably that a considerable degree of acidity exists after operation, and a study of the acid curves shows that a reduction to about half of the pre-operative acidity is the maximum that has been obtained. That is, the gastric secretion is now brought within the limits of normal acidity. An example of this is shown in *Chart IX* (*Fig.* 326). In a minority of cases a condition of hyperacidity persists after operation, as can be seen in *Chart X* (*Fig.* 327), although the high acid level is not now maintained over such long periods, and the acidity of the resting juice is always low. These curves

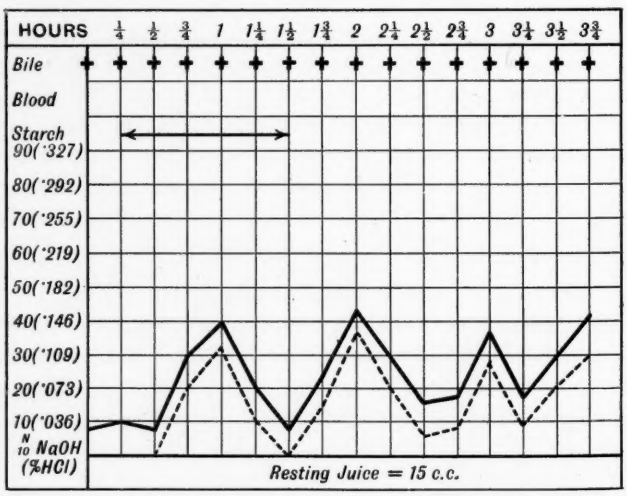


FIG. 326.—*Chart IX.* Duodenal ulcer after gastro-enterostomy with maximum reduction of acidity. Same case as in *Chart VI* (*Fig.* 323).

show a large number of sudden drops in acidity reaching nearly to the base line. This probably indicates the influx of quantities of pancreatic juice at frequent intervals.

In connection with the small reduction of acidity effected by operation, it is interesting to note the much greater frequency with which jejunal ulceration follows gastro-enterostomy performed for duodenal ulcer than when performed for ulceration definitely on the gastric side.

c. Pyloric Ulcer.—The gastric hypersecretion associated with these ulcers is less than that of duodenal ulcer, and a correspondingly greater reduction of acidity is shown after operation. *Chart XI* (*Fig.* 328) shows a typical example. The reduction is to a subacid level, but free HCl always appears at some period of the meal.

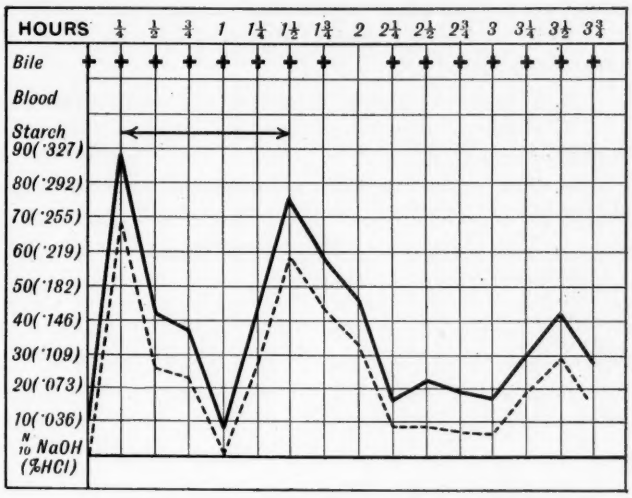


FIG. 327.—*Chart X.* Curve of case shown in *Chart V* (*Fig.* 322) after gastro-enterostomy. Post-operative hyperacidity.

It will be seen from the above observations that the evidence of the fractional test meal is distinctly in favour of the drainage theory as an explanation of the beneficial effects of gastro-enterostomy in chronic ulceration of the stomach and duodenum, since a clinically satisfactory result may be obtained even in the presence of a high degree of post-operative acidity.

The association of delayed emptying after operation with a recurrence of symptoms of pain and vomiting has already been mentioned.

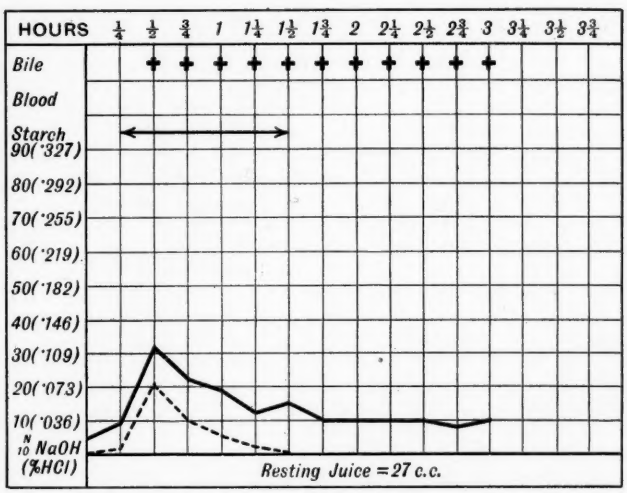


FIG. 328.—*Chart XI.* Pyloric ulcer after gastro-enterostomy. Same case as in *Chart VII* (*Fig.* 324).

Of the cases examined in which gastro-enterostomy had provided but little relief of symptoms, the majority showed an absence of free acid and a very low total acidity. Two of these were operated on again, and no trace of an ulcer was found ; one being the case of achlorhydria referred to above. Two cases of this condition and one of achylia gastrica were met with. They presented symptoms very suggestive of chronic ulceration, and in one of them *x*-ray examination in two different hospitals had led to a diagnosis of ulcer being made—a diagnosis that could have been excluded by a preliminary examination with the fractional test meal.

The view expressed by Sherren[10] that duodenal exclusion is the cause of post-operative hyperacidity is not borne out, as it has been demonstrated that a high acid level after operation is but the natural result of an excessive pre-operative hypersecretion and is not affected by variations in operative procedure apart from the provision of a stoma.

SUMMARY.

1. In performing a fractional test meal the withdrawal of small quantities of gastric juice and their immediate filtration are essential to an accurate result.

2. Ulcers of the body of the stomach are associated with delay and hypo-acidity; duodenal ulcers with hurry and hyperacidity.

3. Ulcers of the pyloric portion of the stomach show a disturbance of gastric function intermediate between these.

4. Bile is invariably found in the stomach after gastro-enterostomy.

5. After a satisfactory gastro-enterostomy, food always leaves the stomach more rapidly than is normal.

6. The post-operative reduction in acidity is greatest in gastric ulcer and least in duodenal ulcer, in which a condition of hyperacidity may remain.

7. The evidence of the fractional test meal supports the drainage theory of gastro-enterostomy.

In conclusion, I wish to express my gratitude to Mr. Geoffrey Jefferson, who has been responsible for most of the operative work involved in this investigation, for his assistance in obtaining the results quoted, and for the many useful suggestions he has offered.

REFERENCES.

[1] Rehfuss, *Amer. Jour. Med. Sci.*, 1914, 848.
[2] Patterson, *Surgery of the Stomach.*
[3] Bonar, *Lancet*, 1921, ii, 953.
[4] Wilensky, A. O., *Surg. Gynecol. and Obst.*, 1922, i, 506.
[5] Wilensky, A. O., *Amer. Jour. Med. Sci.*, 1922, Aug.
[6] Bolton and Goodheart, *Lancet*, 1921, i, 420.
[7] Crohn and Reiss, *Amer. Jour. Med. Sci.*, 1917, 857.
[8] Fowler, Rehfuss and Hawk, *Jour. Amer. Med. Assoc.*, 1915, 1021.
[9] Bolton, *Proc. Roy. Soc. Med.*, 1922, xv, No. 9 (Section of Medicine).
[10] Sherren, *Lectures on the Surgery of the Stomach and Duodenum*, 1921.
[11] Jefferson, G., *Ann. of Surg.*, 1916, March, 329.

CONGENITAL CYST OF THE COMMON BILE-DUCT: WITH REPORT OF TWO CASES.

By JOHN MORLEY, Manchester.

The following are the notes of the two cases on which this paper is based:—

Case 1.—E. R., a girl, age 17, by occupation a domestic servant, was admitted to St. Mary's Hospital, Manchester, on November 1, 1921, under the care of Professor W. E. Fothergill, suffering from abdominal pain and swelling.

History of Present Illness.—Two years before admission she began to suffer from attacks of pain in the right abdomen. The pain was described as sharp in character, as though something was running into her side, and during the past two years she had rarely passed a day without feeling it. The pain was usually at its worst about half an hour after food, and about one hour after a meal she would often vomit, with temporary relief from pain. The vomit was never bile-stained. For several weeks before admission she had noticed that her abdomen was growing larger. Six weeks before admission, after an unusually bad attack of pain and vomiting, the whites of her eyes were yellow for two or three days, but apart from this she had never been jaundiced. She had never noticed the colour of her motions. She had been constipated since her illness began. There had been no loss of weight. Her family doctor sent her to St. Mary's Hospital as a case of (?) ovarian cyst.

Previous Health.—She had convulsions when three weeks old, and has had slight athetoid movements of the hands ever since. Her mental development is slightly defective. Otherwise she has always had good health until the onset of the present trouble.

Family History.—She was the fourth of a family of fifteen. The three children born before her (two male and one female) all died jaundiced, at the age of one month, one week, and two days respectively. One other child, born later, has died at the age of nine months, but without jaundice. The cause of these deaths was not ascertained by post-mortem examination. The rest of the family are healthy.

Condition on Admission.—The girl's nutrition was moderately good, and she was not jaundiced. Considerable abdominal distention was obvious on inspection, and palpation showed a round smooth swelling, tense and cystic, which almost filled the abdominal cavity, with its centre to the right of the mid-line (*Fig.* 329). The tumour was dull on percussion. There was resonance in the left flank and left iliac fossa. On pelvic examination the uterus was normal and appeared to have no connection with the cyst. The fæces were clay-coloured, and the bowels considerably constipated.

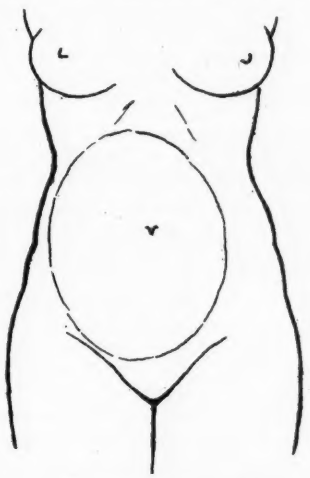


Fig. 329.—Diagram to show the extent of the tumour before the first operation.

First Operation.—Professor W. E. Fothergill explored the abdomen through a vertical incision in the right rectus. A huge cyst was found extending down from under the liver. It was sutured to the parietal peritoneum at the edges of the wound and incised, when many pints of thin, green bile escaped. A drainage tube was inserted and the wound sutured up to it.

Professor Fothergill asked me to take over the patient after this operation. The tube was removed after a few days. Bile continued to escape through the fistula in large quantities, but at the end of three weeks the fistula had nearly closed, and it was evident that the cyst was filling again. During the whole of this period the fæces were clay-coloured.

Second Operation, Nov. 22.—Ether was given by Dr. A. M. Mitchell. The abdomen was opened by an incision through the right rectus, extending rather higher than the previous one and surrounding the biliary fistula at its lower end. On opening the peritoneum above the fistula, a small empty gall-bladder with pointed fundus was seen projecting below the margin of the liver. Below the liver, and adherent to the anterior abdominal wall at the site of the fistula, was a large round cyst, with thick opaque walls, which now contained some two pints of fluid. The cyst was freed from the abdominal wall, and the fistula clamped. During this procedure several ounces of pure bile escaped. Examination of the relations of the cyst demonstrated that it was an enormous saccular dilatation of the common bile-duct. The pylorus and first part of the duodenum were

stretched across the anterior and lower aspect of the cyst, and bound down to it by peritoneum (*Fig.* 330). The second part of the duodenum turned downwards in the normal manner, and only its upper two-thirds lay in intimate relation with the cyst. The duodenum was decidedly distended from the pylorus as far as the point where the superior mesenteric vessels crossed its third part. Beyond this it was contracted. The downward thrust of the cyst on the root of the mesentery appeared to have caused a partial obstruction of the third part of the duodenum between the superior mesenteric vessels and the spine, after the manner of a chronic duodenal ileus.[1]

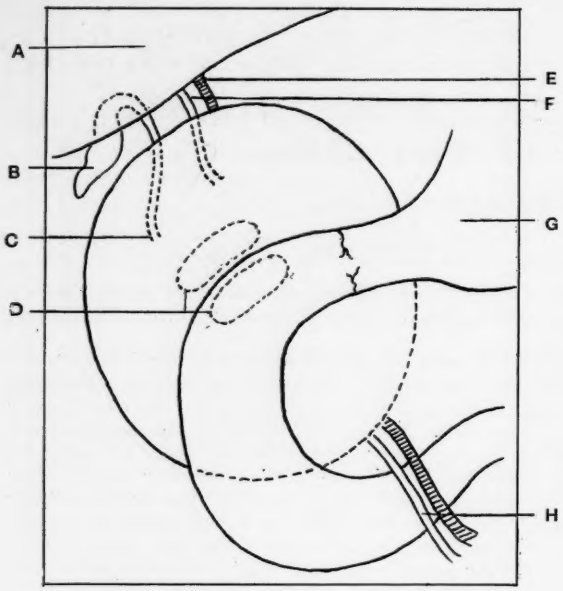


FIG. 330.—Diagram showing relation of parts at second operation. (A) Liver. (B) Gall-bladder. (C) Cystic duct. (D) Site of anastomosis. (E) Hepatic artery. (F) Hepatic duct. (G) Stomach. (H) The superior mesenteric vessels.

A stomach tube was passed at this stage in order to get rid of the troublesome distention of the stomach and upper duodenum. The hepatic flexure of the colon was displaced downwards by the cyst and lay completely below it. As there was evidently no adequate outflow from the cystic dilatation of the common duct into the duodenum, and as the first part of the duodenum lay in easy apposition with the cyst, it was decided to perform a choledocho-duodenostomy. This was done by two rows of fine catgut with the aid of clamps. The cyst wall was quite as thick as that of the duodenum, but tough and fibrous, so that the needle was drawn through it with some difficulty. The clamped external fistula was next packed round with swabs and the clamp removed, when rather more than a pint of green watery bile escaped. The fistulous tract was excised, the opening into the cyst enlarged, and its cavity swabbed dry. It appeared to be lined by a pale mucosa which was intimately adherent to the tough fibrous wall. The slit-like orifice of the cystic duct could now be seen in the right and upper region of the cyst, and a small probe inserted into it passed readily into the gall-bladder. The opening of the hepatic duct into the cyst was not definitely made out, but it was situated more posteriorly and to the left as far as could be made out by external palpation. The hepatic and cystic ducts were not dilated.

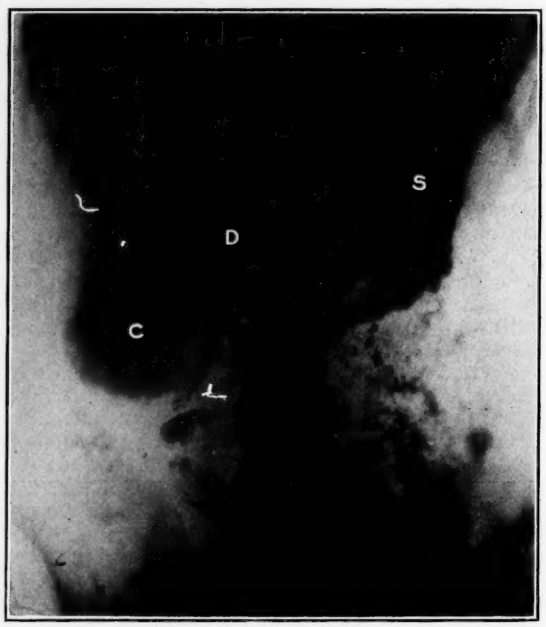


Fig. 331.—Radiogram showing cavity of cyst containing barium after choledocho-duodenostomy. (D) Duodenum. (C) Barium in cyst. (S) Barium pushed into upper part of stomach.

The opening from the cyst via the lower part of the common bile-duct into the duodenum could not be found, though—judging by the absence of icterus—it must have been more or less patent. The stoma from the cyst into the duodenum was examined, and was large enough to admit a finger readily. A small piece of the wall of the cyst was excised for microscopical examination, and the opening in it was sutured in two layers. The abdominal wall was closed without drainage.

SUBSEQUENT PROGRESS.—Bilious vomiting was very persistent for the first week after operation, and caused so much anxiety that I considered the advisability of dividing the stomach at the pylorus, closing the distal end, and implanting the proximal end into the side of the first jejunal loop as in a Polya gastrectomy. From the seventh day, however, the vomiting ceased, and the patient's condition

improved rapidly. The wound healed by first intention. Three weeks after operation an *x*-ray examination after a barium meal was made in order to ascertain whether there was any regurgitation of duodenal contents into the cyst through the stoma. The result is shown in *Fig.* 331, for which I am indebted to Dr. Barclay. Barium is shown passing from the first part of the duodenum through the stoma into the cyst, which is definitely outlined. It has diminished in size considerably. The patient's subsequent convalescence was uneventful, and she reported in November, 1922, that she had been in good health since her discharge from the hospital.

I am indebted to Dr. H. T. Ashby and Mr. H. Platt for notes of the following case, which was under their care in the Manchester Children's Hospital.

Case 2.—H. M., a girl, age 6½ years, was admitted to hospital on September 23, 1915, on account of jaundice, abdominal pain, and wasting.

History.—The child had always been delicate. For the past few weeks the mother had noticed that her skin and sclerotics were yellow, while the stools were pale in colour. The child had complained of intermittent abdominal pain during the same period and had lost weight considerably.

Family History.—The child was one of a family of seven, of whom two children had died in infancy of malnutrition.

Condition on Admission.—The child was moderately well nourished and deeply jaundiced. In the upper right abdomen was a large, smooth, rounded swelling, not tender on palpation, extending from the costal margin down to the umbilicus, and apparently continuous with the liver. There were no signs of fluid in the peritoneal cavity. The swelling was considered to be a cyst, originating in the liver. *X*-ray examination showed no abnormality in the chest, and both domes of the diaphragm were at the usual level, and moved normally on respiration. The blood examination showed 4,500,000 red cells per c.mm. and 8500 leucocytes. Two days after admission the jaundice was noticed to be disappearing, and in a few more days had gone entirely. The tumour diminished in size at the same time, and the child's general health improved.

First Operation.—An *exploratory operation* was undertaken by Mr. Platt on Oct. 23. A vertical incision was made through the upper part of the right rectus. The liver and gall-bladder were found to be normal, and immediately below them a large cyst was found in the position of the common bile-duct. A trocar was inserted and a large quantity of bile escaped. A drainage tube was then inserted into the cyst, and the wound closed up to it. The child's progress for the first few days was satisfactory, but ten days after the operation she showed signs of exhaustion resulting from the profuse discharge of bile from the wound. She improved to some extent after this, though the biliary fistula persisted, and the fæces remained clay-coloured.

Second Operation.—On Dec. 22, two months after the original operation, a second operation was undertaken for the purpose of closing the biliary fistula. The child sank and died a few hours later. No post-mortem examination could be obtained.

Frequency of Cyst of the Common Bile-duct.—Idiopathic cyst of the common bile-duct is a condition of considerable rarity. Erik Waller,[2] who published an exhaustive account of the condition in 1917, was only able to collect 35 cases, including one of his own. Since the publication of Waller's paper, I have only been able to find other cases recorded by Kremer,[3] Budde,[4] McConnell,[5] and Reel and Burrell,[6] making a total, with my own cases, of 41 recorded cases.

Pathological Anatomy.—A study of the recorded cases proves that the disease presents anatomical features that show very few variations of any importance. There is a cystic dilatation of the upper end of the common bile-duct which enlarges slowly and progressively, much like a saccular aneurysm. The hepatic and cystic ducts may open separately into the cyst, as in my own case. The intrapancreatic and the terminal or intramural portions of the common duct are not involved in the cystic dilatation, and in all cases in which the point has been investigated the lower end of the common duct below the cyst has been found to be patent. In Budde's case[4] Vater's ampulla was placed on the front and right aspect of the duodenum.

That obstruction to the flow of bile does occur is evident from the frequency with which jaundice is recorded. The obstruction is, however, often intermittent. Periodical diminution in the size of the cyst has been observed in some cases, with consequent remission of the jaundice. The patent lower end of the common duct usually lies in the medial wall of the cyst, and it would appear that the distention of the cyst with bile gives rise to a valvular obstruction to the common duct at the point where it is suddenly reduced to its normal calibre. The saccular nature of the dilatation, with normal ducts above and below the sac, forms a striking contrast with the diffuse dilatation of the bile-duct met with as a secondary result of gall-stone obstruction, or compression of the common duct by pancreatic tumours.

The size of the cyst varies in different cases, but it is commonly described as the size of a cocoa-nut or a man's head. In my own case (*Case* 1) the cyst so nearly filled the abdomen that the first doctor the patient consulted made the diagnosis of advanced pregnancy. As the cyst enlarges, the first part of the duodenum is sometimes pushed downwards, while the anterior layer of the gastrohepatic omentum is stretched over the anterior wall of the cyst. In other cases, as in my own, the pylorus and duodenum are stretched across the anterior wall of the cyst, to which they are bound down by peritoneum (*Fig.* 330). The hepatic flexure is usually thrust downwards and to the left by the enlarging cyst.

A feature in my case, which has not been recorded in others, was the marked obstruction of the third part of the duodenum by compression behind the superior mesenteric vessels, due to the downward thrust of the cyst on the small intestine and root of the mesentery. It is possible that this condition of secondary duodenal ileus was responsible for the frequent gastric pain recurring an hour or so after food.

The gall-bladder has generally been found to be more or less empty, as in my case, though sometimes it contains enough bile to form a small palpable swelling immediately above the large cyst. In some advanced cases the liver has been involved in biliary cirrhosis, secondary to the obstruction of the duct. The portal vein lies behind the cyst, and the hepatic artery is displaced to the left. The tendency of the cyst as it expands is to grow, from the site of its origin in the supraduodenal or retroduodenal portion of the common duct, downwards and to the right, so that the normal lower end of the duct comes to lie in the left or medial wall of the cyst. This direction of the growth is probably the line of least resistance under the mechanical pressure of the surrounding viscera, notably the liver, which prevents any marked expansion upwards. It will be noted that the cyst primarily encroaches on the subhepatic fossa of the peritoneum, or right kidney pouch.

Structure of the Cyst Wall.—The thickness of the cyst wall varies considerably in different cases. In some recorded cases it has ruptured at once on manipulation by the surgeon ; in others it is described as thick, tough, and opaque. In my case it was about as thick as the duodenal wall, but much tougher, so that it was a matter of some difficulty to push an intestinal needle through it. It was yellow in colour and opaque. Transverse sections of the cyst wall after fixing and staining were 2·5 mm. thick. The histological structure as seen in transverse section was as follows : The mucous membrane lining the cyst had entirely disappeared from the portion examined, and the wall was composed of dense fibrous tissue, with a layer of endothelium on its outer aspect where the peritoneum was adherent to it. A similar absence of the lining mucous membrane was reported by Kremer[3] in sections from his case. In the case reported by Reel and Burrell[6] the cyst was lined by a single layer of columnar epithelium, and the wall contained some isolated lobules of liver cells. Since the cyst was adherent to the liver in this case, it is possible that the lobules may have been stripped off from the liver during separation of the cyst.

Etiological Factors.—

Age.—The average age at which symptoms first arose was from 12 to 14 years in Waller's series of 35 cases. A typical cyst of the common duct, 3 by 2·5 cm. in size, was noted by Heiliger[7] in a full-time fœtus. It was associated with a congenital diaphragmatic hernia. Oxley,[8] in 1883, also reported a case in an infant, age five weeks, in whom the swelling had been noticed from birth. These two cases afford convincing evidence that the condition originates in some congenital defect of the duct. That the enlargement of the cyst is sometimes only very slowly progressive is proved by the case of Reel and Burrell,[6] whose patient, age 56 when operated on, had noticed the swelling from the age of 20. It would appear that the cyst may enlarge slowly for several years without producing symptoms, and that the characteristic symptoms, pain and jaundice, are only produced when the cyst has reached such a size as to cause mechanical obstruction to the duodenum and lower part of the common duct.

Sex.—Of the 41 recorded cases, 36 occurred in females, a percentage of 88 females to 12 males. This marked preponderance of females shows an interesting parallel with the sex relationship in congenital dislocation of the hip, and its explanation is equally obscure.

Heredity.—There is little evidence that hereditary influences bear any part in the etiology of the condition. It is suggestive that the three children in the same family who

were born before my patient all died, jaundiced, at the age of one month, seven days, and two days respectively; but in the absence of post-mortem examinations this evidence can hardly be regarded as of any scientific value.

We have, therefore, to deal with a localized dilatation of the common bile-duct, congenital in origin, and very slowly progressive. Its precise mode of origin and its causation remain obscure. A study of the embryological accounts of the formation of the liver and bile-ducts as an outgrowth from the hypoblast of the intestinal canal at the junction of the foregut and midgut does not throw any light on the formation of this rare anomaly.

In Budde's case,[4] the opening of the common bile-duct into the duodenum was not at the usual position on the postero-internal aspect of the second portion, but more on the right and anterior aspect of this part of the duodenum. This position of Vater's ampulla would appear to indicate some abnormality in the rotation of the midgut loop and peritoneal fixation of the duodenum, which may prove to be the prime cause of the dilatation of the bile-duct. The point requires further attention, and wherever possible in future cases the precise position of the lower end of the common duct should be recorded. Budde considers that these cysts are due to congenital dilatation of the extraduodenal part of the common duct, increased by valvular obstruction at the lower end, and by inspissation of bile. He ventures the suggestion that the primary diverticulum is due to a pancreatic rest in the wall of the choledochus, the cells of which break down, and thus originate the dilatation of the duct. This dilatation increases progressively as a result of the tension of its contents. This conception is based on the analogy of the well-known diverticula of the duodenum, which often contain pancreatic tissue. There does not appear, however, to be any solid histological foundation for his ingenious theory, since in no recorded case of choledochus cyst has pancreatic tissue been found.

Symptoms and Signs.—The clinical manifestations consist of attacks of abdominal pain, associated with a tumour, and usually with jaundice. The attacks of pain recur at varying intervals, but tend to grow more severe and more frequent as the cyst enlarges. The pain varies in intensity in different cases: in some it is described as a feeling of flatulence, or acute indigestion, is worse half an hour or so after meals, and is usually relieved by vomiting. In others there are less frequent but more severe attacks of a colicky or spasmodic nature. The pain is usually referred to the epigastric region. It has been suggested above that the pain may be due, in some cases at least, to partial obstruction of the third part of the duodenum by the superior mesenteric vessels.

The tumour varies greatly in size. When small it lies under the upper right rectus. When very large it may fill almost the entire abdomen except the right iliac fossa. Fluctuations in size have been recorded, and the cyst has been noticed to be more tense and prominent after meals in some cases. In others there have been periods in which the tumour has become smaller, and the pain and jaundice less severe, or absent; but in spite of these occasional remissions, the tumour tends gradually to enlarge.

Owing to the position of the cyst immediately below the liver, the liver margin is thrust up under the lower ribs, and can seldom be palpated, though cases are recorded in which a distended gall-bladder has formed a palpable swelling immediately above the cyst. The dullness of the tumour on percussion is continuous with that of the liver, but on account of its peritoneal fixation the cyst does not move up and down so distinctly on respiration as does an intrahepatic cyst.

Jaundice has been a marked feature in the great majority of recorded cases. In Waller's case and in my own, there was only slight tinging of the sclerotics for a short time, but much more commonly it has been quite unmistakable for some time before operation. In some of the cases with the largest cysts, ascites from pressure on the portal vein, or œdema from pressure on the inferior vena cava, has occurred.

Diagnosis.—The great rarity of the condition is undoubtedly responsible for the lack of a correct pre-operative diagnosis in any recorded case. The association of a typical subhepatic cystic swelling with jaundice and attacks of epigastric pain in a girl of 14 to 20 years, should lead one who is familiar with the literature to a correct diagnosis.

The physical signs are not easy to distinguish from those of hydatid cyst of the liver or pancreatic cyst. The former, however, rarely produces pain, and moves more freely

on respiration and on palpation than does a cyst of the common bile-duct. Examination of the liver by *x* rays, after inducing pneumoperitoneum, would probably demonstrate the intrahepatic situation of the hydatid cyst. Pancreatic cysts, with the exception of pseudocysts in the lesser sac of the peritoneum, seldom attain a size comparable with that usual in cyst of the common bile-duct, and the pseudocysts are invariably preceded by severe trauma. It must be admitted, however, that a cyst arising in the head of the pancreas might produce symptoms and physical signs that could not be distinguished with any certainty from cyst of the common bile-duct.

Treatment and Prognosis.—Two factors have combined to give a deplorably and quite unnecessarily high death-rate to the cases that have hitherto been operated upon. In the first place, operation has been deferred until the patient has become profoundly ill from jaundice, with pain and vomiting, and is little able to stand a major operative procedure. In the second place, and more important, the operating surgeon has too often been unfamiliar with the condition, and has consequently adopted inappropriate measures. Three cases have been treated by extirpation of the cyst through failure to recognize that the 'cyst' was an essential though abnormal part of the common bile-duct. These cases were inevitably fatal. Twenty-two cases have been treated by incision and external drainage. Of these, 20 have died (one survived three years with a fistula, and died of phthisis) while 2, Reel and Burrell's case[6] and McConnell's case[5], were in good health when the case was reported, though one required secondary drainage of an abscess in the sac. This abscess apparently led to shrinking of the cyst. The formation of an external biliary fistula plainly affords very little hope of relief for the patient. It is less disastrous than extirpation of the sac, but a permanent leaking of bile from the wound is a deplorable prospect for the patient. Moreover, the fistula tends to close, when the swelling of the cyst will usually recur.

The only rational treatment consists in the formation of a permanent anastomosis between the dilated bile-duct and the alimentary canal. The stomach, duodenum, or jejunum may be utilized; but a fistula with the duodenum gives the nearest approximation to the normal, and is to be preferred, as it presents no great technical difficulties. Of 3 cases in which a primary anastomosis was made, 2 recovered and 1 died. In the fatal case the cyst was drained externally at the same time. Primary drainage, with choledocho-enterostomy as a secondary operation, was performed in 8 cases. Of these, 5 recovered and 3 died; but in the three fatal cases it would appear that the attempt at anastomosis was not altogether successful.

Primary lateral choledocho-duodenostomy, without drainage, would appear to be the operation of choice. It is necessary to evacuate some of the contents of the cyst in order to effect the anastomosis, but this can readily be done with an ovarian trocar or a large exploring syringe. Temporary external drainage of the cyst may be adopted as a palliative measure if the patient is in a critical condition; but the prospect of lasting relief from drainage is remote, and the anastomosis should be undertaken as soon as the patient's condition warrants it. In the event of severe post-operative vomiting, division of the pylorus, with invagination of its distal end, and implantation of the proximal end into the side of the first jejunal loop, may be considered, but it is certainly not required as a rule.

I am indebted to my colleague, Professor W. E. Fothergill, both for the opportunity of operating on the case herein recorded, and for the two diagrams illustrating the condition.

REFERENCES.

[1] Wilkie, D. P. D., *Brit. Jour. Surg.*, 1921, ix, 204.
[2] Waller, E., *Ann. of Surg.*, 1917, lxvi, 446 (with bibliography).
[3] Kremer, J., *Arch. f. klin. Chir.* 1919–20, cxiii, 99.
[4] Budde, M., *Deut. Zeits. f. Chir.*, 1920, clviii, 364.
[5] McConnell, A. A., *Brit. Jour. Surg.*, 1919, vii, 520.
[6] Reel, P. J., and Burrell, N. E., *Ann. of Surg.*, 1922, lxxv, 191.
[7] Heiliger, quoted by Waller, loc. cit.
[8] Oxley, *Lancet*, 1883, ii, 988.

SHORT NOTES OF RARE OR OBSCURE CASES

ACUTE HÆMORRHAGIC PANCREATITIS: ROUND WORM IN PANCREATIC DUCT.

By Sir HUGH M. RIGBY, K.C.V.O., London.

The patient, Annie Barker, a domestic servant, single, age 30, was admitted to the London Hospital on Jan. 21, 1909, with the following history.

On the previous day, whilst at work, she was seized with sudden severe pains in the abdomen. The pain was cutting in character and was chiefly located across the lower part of the abdomen and in the back. She vomited ten minutes after the onset of pain, and, during the rest of that day, the pain continued and she had constant vomiting and shivering attacks.

To-day (Jan. 21) she still complains of pain, chiefly in the left iliac fossa. The sickness has stopped, though she still has nausea. The bowels have not acted for two days. In the evening, her general condition was grave.

Physical Signs.—Patient not very fat; there is no note of any marked cyanosis. Pulse 120, small and rather irregular. Respiration 30. Temperature 100.° Tongue dry. Inquiries elicit no history of previous gastric trouble. Menstrual history normal.

On examining the abdomen, no appreciable distention can be made out. The abdominal wall is rather rigid; there is some movement of the lower abdomen on respiration; superficial tenderness and pain on palpation, most complained of over the lower abdomen. There is no evidence of free fluid in the peritoneum.

Diagnosis.—Not clear, but seemed to lie between acute appendicitis and perforated gastric or duodenal ulcer. Operation was carried out soon after admission.

Operation.—Abdomen was opened by a median incision below the umbilicus. A quantity of reddish, odourless fluid escaped, and a hurried examination of the appendix region and pelvic organs revealed no evidence of disease. A tube was passed down to the pelvic floor and the incision covered up.

A second incision was then made above the umbilicus in the middle line. A quantity of similar reddish fluid escaped, and then extensive fat necroses were seen scattered about on the omentum and mesentery. The lesser sac was now opened up by tearing a way through the lesser omentum; still more reddish fluid escaped in this region. The pancreas was then seen to be greatly swollen; it was maroon-coloured and mottled on the surface, and the substance was soft and sponge-like; its anterior surface was scratched through.

The cavity of the lesser sac was washed out with boric acid, and gauze tampons were passed down to the surface of the pancreas. The gall-bladder and region of the common duct were examined: there was no obvious sign of disease, so the gall-bladder was not drained. Both abdominal wounds were partially closed, a drainage tube being left passing down to the floor of the pelvis.

The patient stood the operation fairly well. Rectal saline was given, and during the night a large quantity of fluid drained away from both wounds. Next morning her condition was not improved. She still had some pain—not very severe. Temperature 101.° Pulse 120. Towards evening her condition became much worse. She had incontinence of urine: pulse, weaker, 140 per minute: respirations 44 to 50 per minute: she died suddenly at 10 p.m., after vomiting.

Before the operation, a specimen of urine had been saved for examination. Analysis showed a trace of albumin, but no sugar. Cammidge's pancreatic test was positive.

The fluid removed from the abdomen was examined, and found to be faintly alkaline and to contain an active starch-splitting ferment: very slight digestive power on albumin. Deposit of the fluid contained blood and numerous pus cells: no organisms in films. Cultures sterile.

POST-MORTEM EXAMINATION.—The following is an abstract of the notes:—

Macroscopic diagnosis: Hæmorrhagic pancreatitis. Fat necroses were found throughout the peritoneum, including the under surface of the diaphragm. Operation drainage tubes in lesser sac and in the pelvis. Cloudy, sanious fluid in the lesser sac.

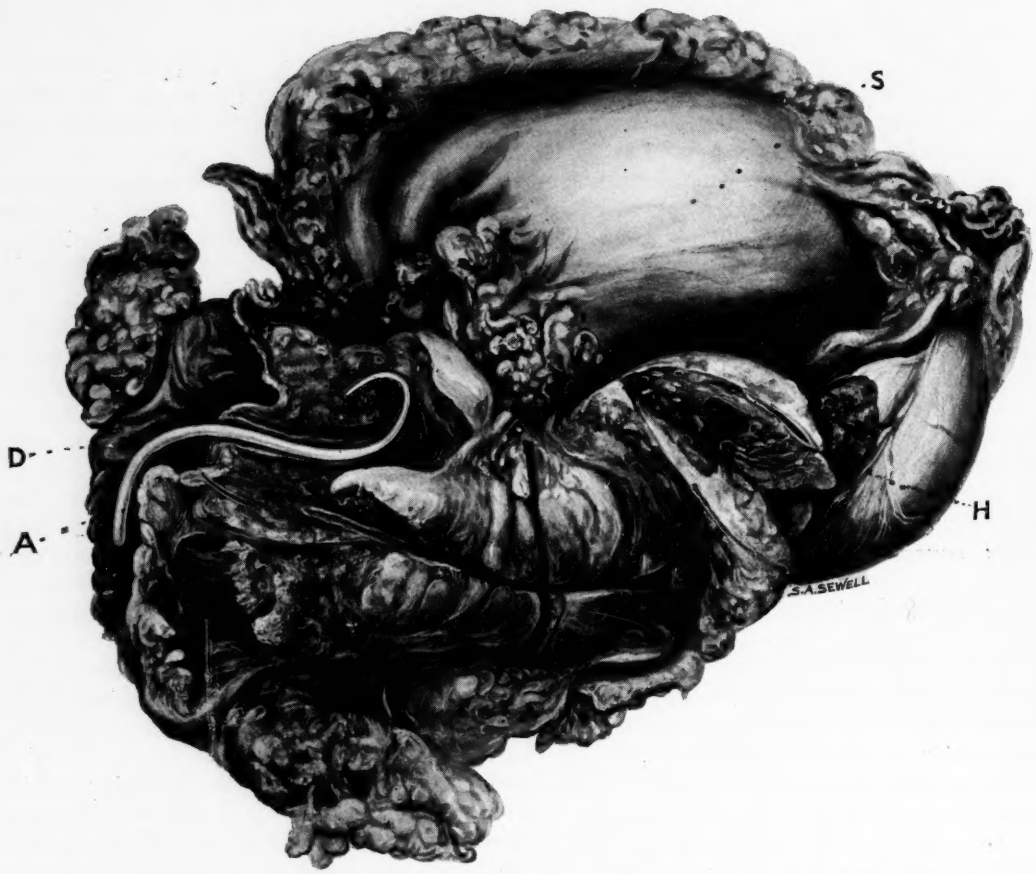


FIG: 332.—Round worm found post mortem in pancreatic duct. (D) Duodenum. (A) Worm in duct. (S) Stomach, turned up. (H) Hæmorrhage in pancreas.

Some pus in the pouch of Douglas. Hyperæmia of visceral peritoneum with early fibrinous peritonitis.

On opening up the duodenum, part of an *Ascaris lumbricoides* was found projecting from the ampulla of Vater into the lumen of the gut (*Fig.* 332). The pancreatic duct was then split up, and the body of the ascaris was found passing along the duct and then turning round into the duct of Santorini, so that both ducts were effectually blocked. Bile staining of the terminal inch of the duct of Wirsung, and dilatation of the common bile-duct were present, and bile could easily be expressed from the gall-bladder into the duodenum. Great congestion of the lungs. Liver fatty. Moderately fat woman. Healing varicose ulcer was found on the left calf.

PARTIAL OBSTRUCTION OF THE PANCREATIC DUCT BY ROUND WORMS.

By Lieut.-Colonel NOVIS, I.M.S., Bombay.

The presence of worms in the pancreatic duct must be rare, and though these parasites often inhabit the intestine in Eastern countries, on no previous occasion have I found them blocking a duct, but have frequently observed them free in the peritoneal cavity in cases of perforation of the intestine: and in one of my cases a bunch of fifty-nine worms caused acute obstruction.

B. H., a Hindu female, age 12 years, was admitted to hospital on April 6, 1922, for recurring attacks of severe abdominal pain.

The history, as is usual with Indians of the hospital class, was indefinite. Her appetite had been poor, and she had had no desire for food for some weeks. Eight days previous to admission she was suddenly seized with severe pain of a colicky nature in the abdomen, and vomited once; after two or three hours the severe symptoms subsided, leaving a dull continuous pain in the epigastrium. Similar attacks occurred at irregular intervals (once or twice in forty-eight hours), but there was no further vomiting. Her health in the past had been good, and, as far as could be ascertained, she had had no previous abdominal trouble.

On Admission.—The patient was thin, but her condition was fairly good. Pulse and respiration normal; temperature 99°. Abdomen: no distention. The recti were rigid over an indefinite tender swelling in the epigastrium; but the rest of the abdomen was quite soft, and moved freely. Motions were regular and to all appearances normal (unfortunately no analysis was made). Urine was normal.

The patient was kept under observation for some days, during which time she had several severe attacks resembling renal or biliary colic, which had no relation to food or movement. The temperature varied from normal to 101°, but lacked the regular characters of a septic chart. Blood and *x*-ray examinations did nothing to further the diagnosis, except from a negative point of view.

A provisional diagnosis of pancreatitis was made. Laparotomy was performed on April 17, and a greatly enlarged pancreas exposed between the stomach and transverse colon. The stomach, gall-bladder, bile passages, and the ampulla of Vater were palpated to exclude calculus, and found normal. An incision was then made in the pancreas from head to tail, opening the pancreatic duct, from which a full-sized living round worm and a partially disintegrated one were extracted. The incision in the pancreas was united with interrupted catgut sutures and the abdomen closed, leaving a soft rubber cigarette drain down to the pancreas, which was removed after forty-eight hours.

During convalescence several round worms were passed after administration of santonin, and the patient was discharged on May 10, looking fat and well, with a healthy appetite. There was no recurrence of pain after the operation.

INTESTINAL OBSTRUCTION FROM HYDRONEPHROSIS IN A PELVIC KIDNEY.

By H. TEMPLE MURSELL, O.B.E., Johannesburg.

The following case appears to be of sufficient rarity to justify record:—

In January, 1921, a male patient, age 41, was sent to the writer by his doctor, with the following history. For the past year or more he had been suffering from attacks of intestinal obstruction, accompanied by a palpable tumour just above the bladder in the middle line, which seemed movable; the tumour became softer when the attack passed off, but never entirely disappeared. Two medical men who saw the case regarded it as

a bowel tumour causing a constriction of the lumen. These attacks became more prolonged, until one of them lasted twenty-four hours. When seen by his doctor there were typical signs of obstruction, vomit was already evil-smelling, there was much colicky pain and visible peristalsis ; but the pulse was still slow and strong. As on previous occasions, an enema had immediate results, fæces and flatus being passed with considerable relief. Twenty-four hours later, the symptoms recurred in an aggravated form, the face having a pinched appearance, the breath being foul, and jaundice being present. As the condition was most urgent, his doctor operated immediately at the patient's farm, many miles away from any large centre. The condition found was " a tumour, the size of a big fist, lying over the sacral promontory, and in the layers of the mesentery which was tightly stretched over it, the bowel below this being collapsed. The tumour was fluctuant, and except for hanging over the brim of the pelvis, was sessile. After packing off, the swelling was incised and the contents were found to be urine. On examining the inside of the cyst two dimples were found, but no openings therefrom could be made out. The bladder was filled up with boric lotion, but none appeared in the cyst. The lining of the cyst resembled that of the urinary bladder, and it had a distinct muscular wall apart from the mesenteric layer. It appeared, therefore, to be either a sacculation of the bladder or an enormously dilated ureter. The sac was drained by a rubber catheter and attached to the parietal peritoneum. Three days later the sac was found to drain out about 8 oz. of blood-stained urine to every 10 oz. of clear urine passed per urethram. The bladder urine contained no albumin. There was the history of a bullet wound in the region of the left kidney in 1914, making it not improbable that left ureteral stricture might have ensued. All symptoms of intestinal obstruction subsided and the patient's general condition is excellent."

So far, the history is that given by his own doctor, who, faced with a case of extraordinary difficulty, dealt with it with great judgement and under most trying conditions.

On Jan. 29, 1921, the patient was admitted to the Johannesburg Hospital under the writer's care. A Jaques catheter was still draining the median suprapubic wound, and urine escaped therefrom. There was pus in the catheter urine, none in that passed per urethram. The specific gravity and the urea percentage differed in the urine from the two sources. An attempt at pyelography, by means of collargol injected through the sinus, failed owing to insufficient collargol being available. The use of sodium bromide for the purpose was not known to the writer at that time. Cystoscopy revealed no evidence of bladder diverticulum. Catheterization of the left ureter gave a free secretion of a normal urine. Methylene blue injected through this left ureteral catheter flowed back into the bladder, but was not evacuated through the catheter in the sinus. Hence the sinus, whatever its character, had no communication with the left kidney and ureter. Methylene blue by the mouth was excreted both by the urethra and by the sinus catheter. Hence the sinus could be stated to communicate with the right kidney or ureter. A ureter catheter would only pass one third of an inch on the right side, hence there was obstruction of some kind, and the right renal pelvis could not be injected from below.

Operation.—On Feb. 14, 1922, the writer made an oblique right lumbar incision, Dr. Brebner assisting. No kidney was found in the right loin. The former anterior median incision was re-opened, and the right kidney found at the brim of the true pelvis. The loin incision was extended downwards and forwards, the kidney pushed up into it by the assistant's hand in front. A hydronephrotic kidney was removed. No true pedicle could be separated out so as to define the vessels and ureter accurately. Ligation was made through the hugely distended but flabby pelvis, and the kidney and as much as possible of the pelvis were removed.

On examination, little secreting tissue remained in the removed kidney.

The patient made an excellent recovery, and has been at work as usual on his farm since. This can reasonably be accepted as a congenitally misplaced kidney with subsequent hydronephrosis causing the unusual complication of intestinal obstruction.

Up to the last attack the renal distention was apparently intermittent ; but at the time of examination and operation was probably permanent.

PELVIC HÆMATOCELE IN A MALE, UNNOTICED UNTIL INFECTED FROM THE INTESTINE.

By W. G. SPENCER, London.

In January, 1916, a private, serving in Egypt, strained himself lifting ammunition, and subsequently he noticed a left inguinal hernia. In July of the same year, in France, an explosion rendered him unconscious for two days. He was subsequently admitted to the Maudsley Hospital on account of shell-shock; afterwards he was transferred to the 4th London General Hospital, and next to a convalescent home, where, after three weeks, he was operated upon for left inguinal hernia. The prolapsed omentum was transfixed and ligatured tightly. He got up after three weeks, and was considered fit for active service. Five weeks after the operation for hernia, in November, 1916, he was seized with difficult micturition without apparent cause, and a swelling was found in the hypogastrium which was not removed by the passage of a catheter. His temperature rose to 102°. There was a tense swelling in the centre of the hypogastrium, reaching two-thirds of the distance from the pubes to the umbilicus. It was dull to percussion, could be swayed from side to side, did not bulge into the rectum, and remained unaltered when a catheter was passed, through which less than 2 oz. of urine escaped.

It was supposed that he had an abscess in the cavum Retzii. After making an incision and separating the recti, indurated tissue was reached, but on scratching through this the bladder was opened. After suturing the walls of the bladder an opening was made just above, when a quantity of greenish-blue thick fluid escaped from a smooth-walled sac situated within the peritoneal cavity. No actual clot was met with. The cavity was drained for a few days, after which the wound healed without complications.

It is not clear whether the strain or the explosion was the cause; there is a third possibility—hæmorrhage from the stump of omentum after the hernia operation; but there was no sign of omentum in the abscess. At any rate, the condition passed unnoticed until infected from the intestine.

ENDOTHELIOMA OF THE LEFT KIDNEY EXTENDING DOWN THE URETER AND PROJECTING INTO THE BLADDER: REMOVAL: DEATH FOUR MONTHS LATER.

By W. G. SPENCER, London.

On June 15, 1915, a woman, age 45, was admitted to the Westminster Hospital complaining of hæmaturia and a lump in the left loin. For two years she had passed blood in the urine at irregular intervals, but in her mind this was confused with equally irregular attacks of menorrhagia. She had had pain in the left loin on and off for six months, and for a fortnight had noticed a lump there.

The left loin was filled by a firm tumour of the shape of the kidney and about three times its size; it was not tender, and had the descending colon in front of it. Through the cystoscope a cauliflower-like growth was seen projecting from the left ureteral orifice. The base of the bladder was free from induration, but through the rectum the left ureter could be traced upwards, forming a cord the thickness of the finger.

On June 25, a transverse incision was made immediately above the pubes, and continued outwards, parallel to Poupart's ligament. This was deepened through the abdominal wall without opening the peritoneum until the bladder wall was exposed around the end of the ureter. The bladder was then opened, and the interior found quite healthy except for a friable papilliferous growth the size of two thumbs, attached to the ureteral orifice by a narrow pedicle. A ring of bladder wall including this was cut out,

and on dividing the ureter between clamps it proved to be thickened to the size of the finger by infiltration of its wall and not by the dilatation of its lumen. The abdominal incision was now carried upwards over the line of the ureter into the loin and the peritoneal cavity opened. The hand in the peritoneal cavity failed to discover any extension of the disease outside the capsule of the kidney, and the kidney and ureter were readily removed. Whilst this part of the operation took thirty-five minutes, the suturing occupied twice that period; one drain was placed in the loin, and another between the front of the broad ligament and the bladder. Healing occurred without complication, and the patient was discharged at the end of the month. She was seen once afterwards, apparently doing well; but four months after the operation she was admitted to the Infirmary in a very weak state, complaining of pain in the left loin and over the pubes. The abdominal scar was sound, and nothing was discovered on palpating the abdomen. There was no post-mortem examination.

Pathological Description (*by the late Dr. R. Hebb*).—The kidney tumour removed had retained approximately the shape of the kidney, and was about three times the size. On section, the pelvis and calices were found dilated and filled with whitish, semi-fluid grumous material; the solid part was formed by a vascular new growth. Microscopic sections showed large alveoli lined by columnar cells, but the cells towards the centre of the alveoli were spheroidal. Blood-vessels were seen in the walls of the alveoli. The ureter was regularly thickened and œdematous, the œdematous tissue being formed by soft myxomatous malignant infiltration, chiefly composed of small round cells of a lymphatic type. The growth in the bladder had the structure of a villous tumour, a central blood-vessel being surrounded by endothelioid cells. Dr. Hebb considered the disease to be an endothelioma.

Presumably death followed infiltration by the growths of the region of the solar plexus and receptaculum chyli.

LARGE INTRAPERITONEAL (? PAROVARIAN) CYST DISAPPEARING AFTER DRAINAGE.

By W. G. SPENCER, London.

The patient, age 54, had suffered from indigestion all her life, but otherwise was in fairly good health up till three years previous to admission; at that time, soon after the menopause, the abdomen rapidly increased in size, and at the end of one month was enormously distended. She was then admitted to the Lambeth Infirmary and the abdomen was tapped; a large quantity of fluid was withdrawn. For a short time the abdomen remained normal in size, but soon filled again. Altogether the patient was tapped four times in two months. She was then discharged from the Infirmary, and remained fairly comfortable for a period of two years.

When admitted to the hospital in June, 1916, the patient was much wasted and very weak; the abdomen was enormously distended; a rectocele of the size of two fists was protruding through the anus. On further examination, the abdomen was found to be distended with fluid which gave a marked thrill. The protrusion was most marked towards the middle line as compared with the flanks; in the epigastrium the protrusion was resonant; the rectocele was irreducible owing to tension, and on the protruding part was an ulcer the size of a five-shilling piece. The most probable diagnosis seemed to be that of a ruptured ovarian cyst.

Under general anæsthesia a small incision was made in the middle line below the umbilicus, and *twenty pints* of thin brownish fluid were drawn off. The opening was then enlarged, and the hand inserted into the cavity of an enormous unilocular cyst which contained many handfuls of soft white fibrin. The whole of the cyst cavity was explored with the hand; it consisted of a thin wall which had become closely united by vascular adhesions to the parietal peritoneum, and practically fused with it near the edge of the

incision. The viscera could be felt through it ; the uterus and ovaries were quite in place, the uterus being not at all prolapsed. At the upper part of the cyst all the small intestines seemed to be bunched up in front of the pancreas ; there was no enlargement of the liver or any other abdominal viscus. The rectocele disappeared with the evacuation of the cyst.

It was assumed from this exploration that the patient must have had a unilocular thin-walled parovarian cyst, which probably prolapsed and became fixed in the pelvis, and then slowly expanded upwards, pushing the intestines before it.

Two large tubes were inserted in the cyst cavity, and the rest of the wound was sewn up.

An examination of the fluid from the cyst by Dr. Hebb showed it to be highly albuminous, with an alkaline reaction. No reaction for urea (hypobromite). No crystals (with nitric acid) of urea nitrate. There were a deposit of pus and a few red blood-corpuscles.

The patient recovered well from the operation. The cavity slowly obliterated, and finally healed up completely in December of the same year, 1916.

Dec. 2, 1921.—The patient had remained well, but came to the hospital again on account of varicose veins, for which bandages were ordered. Except for a small firm scar in the hypogastrium the abdomen appeared normal in all respects, and she had no abdominal disturbance of any kind.

TWO CASES OF RUPTURED SIGMOID COLON.

By R. M. HANDFIELD-JONES, London.

The two cases published by Mr. W. G. Spencer in the October number of The British Journal of Surgery bring to mind two somewhat similar cases in my own experience, each of which shows points of unusual interest, though not the same in each.

Case 1.—A man, age 63, was admitted to St. Mary's Hospital at 10.30 p.m., complaining of very intense abdominal pain. He assured me that he had felt perfectly well that morning, and had never had a day's illness in his life. There was not one single symptom which could in any way attract attention to the large bowel. His bowels were opened regularly every morning, and he had not suffered with diarrhœa. His relatives corroborated his story afterwards. On this particular day—Sunday—he had a large dinner at midday, and tea at 4.30 p.m. Without the slightest warning, at 6 o'clock he was smitten with violent abdominal pain, and vomited once. At 7 p.m. he had a hot bath, which for a short time relieved the pain, but this was only temporary. On his admission to hospital I diagnosed the rupture of some hollow viscus. He was in a very collapsed condition, and still in acute pain. He was given a small intrathecal injection of 5 per cent novocain ; but he was unable to withstand the resulting additional fall of blood-pressure. He was returned to bed, where he died almost immediately. The autopsy revealed an annular carcinoma of the rectosigmoidal junction, and three inches above this a perforation of the colon, with widespread flooding of the peritoneal cavity with fæces. I think that the interest of this case is, first, the entire absence of premonitory symptoms, and, secondly, the extraordinarily short space of time between the onset and the fatal result.

Case 2.—A man, age 56, had been attending his medical man for the past three years for mucous colitis, during the whole of which time he had been apparently passing blood and mucus per anum. For the week prior to admission he had been very constipated, and had been unable to get his bowels to act. That afternoon he had suddenly been seized with violent abdominal pain, and had been sick. He was seen at about 10 p.m., when he had a distended abdomen with marked tenderness and rigidity over the whole infra-umbilical region. His abdomen was opened by a median incision, and there was

found to be considerable fæcal fouling of the peritoneum. The whole colon was distended, and the lower part full of firm fæces. A small annular carcinoma was found at the rectosigmoidal juncture, and at the apex of the sigmoid loop was a circular gangrenous area the size of a five-shilling piece ; in the centre of this was a perforation the size of a shilling. The loop was emptied as far as possible, and a Paul's tube tied in. He did not survive the night, and the autopsy confirmed the operation findings, and in addition showed multiple diverticula in the whole length of the colon, quite as numerous in the ascending colon and cæcum as in the sigmoid colon.

I believe I am quoting Sir Berkeley Moynihan correctly when I say that he teaches that diverticula in the ascending colon and cæcum are exceedingly rare ; and I think this case interesting for that reason. In addition, it would appear that the flooding of the peritoneum with the contents of the large intestine is a very different proposition in regard to prognosis from similar lesions of the upper part of the gastro-intestinal tract.

REVIEWS AND NOTICES OF BOOKS.

Surgical and Mechanical Treatment of Peripheral Nerves. By BYRON STOOKEY, A.M., M.D., Assistant in Neurology, Columbia University, New York, with a chapter on Nerve Degeneration and Regeneration by G. CARL HUBER, M.D., Professor of Anatomy in Michigan University. Large 8vo. Pp. 475, 217 illustrations (8 in colour), and 20 charts. 1922. Philadelphia and London: W. H. Saunders Co. 48s. net.

INTEREST in the surgery of peripheral nerves is stimulated by every war, for it is only then that sufficient material can be obtained for study. The American Civil War called forth the work of Weir Mitchell, Morehouse, Keen, and the two later works of Weir Mitchell. The nerve injuries of the Boer War made possible the work of Head and Sherren.

This volume adds yet another to the books resulting from the experience gained in the late European War, and is the result of the author's well-known work on the subject. It opens with a comprehensive account of the general anatomy, human and comparative, naked eye and microscopic, of the spinal nerves. The individual nerves are very fully dealt with in each section before dealing with the surgery of those nerves.

The chapter written by Huber on degeneration and regeneration is an admirable account of the subject, and summarizes in an excellent manner our present knowledge. Nerve repair and operative technique are dealt with fully, and the sections are admirably illustrated.

In the section on sensory examination the following statement appears: "By this procedure Stookey (1916) demonstrated the sensory area of the musculospiral nerve on the dorsal part of the distal phalanx of the thumb, theretofore attributed to the median nerve." This is incorrect; the area was correctly figured and described by Head and Sherren in 1905.

The chapter on indications for operation is particularly good. The various operations on the facial nerve are fully described, and an adequate review of the whole subject is presented. In the chapters devoted to a study of injury of individual nerves there is a curious and very important omission which detracts considerably from the value of the work. No account is given of the sensory loss resulting from injury, and no illustrations are shown of it. Much of the minute anatomy could be spared, and many of the illustrations of the ultimate distributions of nerves to muscles, which, while of interest to anatomists, have in many cases little surgical value. Their place should be taken by a full account of the result of injury on sensation.

In the article on causalgia no account is given of its symptoms, and although in the bibliography Weir Mitchell, Morehouse, and Keen are quoted, the description written by them of this condition, which has never been surpassed, is not mentioned in the text. This is taken up with discussions on the value of alcohol injections and perivascular sympathectomy in treatment. There is no help given in recognizing the condition and diagnosing it. At the end of this chapter other painful conditions following injury are dismissed in six lines. Throughout the whole of the book this almost complete neglect of the sensory phenomena following nerve injury detracts from its value. To neurological surgeons who are familiar with this side of the question the attention given to the motor side and the chapters on treatment make it a book to read.

The Practice of Surgery. By RUSSELL HOWARD, C.B.E., M.S., F.R.C.S., Surgeon to the London Hospital, Senior Surgeon to the Poplar Hospital, London. Third edition. Medium 8vo. Pp. 1280. 1922. London: Edward Arnold & Co. 30s. net.

A TEXT-BOOK of general surgery written by a single author has very many advantages compared with the multiple-author system. There is an absence of overlapping, a balance in the proportioning of space, and a breadth of view which are sometimes difficult of attainment even by the most exacting of general editors.

There is no doubt that the undergraduate prefers a one-man book, and when it fulfils his purpose in the way this text-book does, it becomes deservedly popular. The present edition has been brought up to date, and its teaching in almost every respect conforms with modern views. One would have to be almost hypercritical to find fault with it as a sound book for pre-graduate study.

For the practical surgeon, it lacks the discussion of surgical principles and methods, which help the individual to choose for himself, and operative details are referred to only in general terms. The printing and illustrations are of a high order, and fairly representative conditions have been selected for depiction. The student who reads and digests this book will have a sound basic knowledge of the scence and art of modern general surgery.

The Surgical Diseases of Children: a Handbook for Students and Practitioners. By FREDERICK C. PYBUS, M.S., F.R.C.S., Assistant Surgeon, Royal Victoria Infirmary, Newcastle. Demy 8vo. Pp. 408 + xviii, with 288 illustrations. 1922. London: H. K. Lewis & Co., Ltd. 18s. net.

THIS book represents the practical clinical teaching of the author in the wards of a children's hospital. We feel quite sure that the actual demonstrations, of which this is the mere book of words, were full of practical value, and the collection of illustrations, most of them photographs, is in itself most attractive.

The text, however, is disappointing because it is so elementary. Apart from the illustrations the book does not give as much information about the important surgical diseases of childhood as is to be found in a general text-book. Such subjects as cleft palate, club-foot, congenital dislocation of the hip, infantile paralysis, and surgical tuberculosis, about which we might naturally expect full and explicit teaching as to treatment, are dealt with very much as we find them in an ordinary text-book. On the other hand, there is a disproportionate presentation of rare abnormalities of little surgical importance, such for example as supernumerary digits, club-hand, and pseudo-coxalgia. In the article on fractures, the suspension method of treating fractured femurs in children is not dealt with, whilst the treatment by plating is mentioned and illustrated.

As an elementary exposition of surgical practice, as seen in a children's hospital, the book is short, simple, and clear, and as such would be invaluable for nurses and dressers.

Cancer of the Breast and its Treatment. By W. SAMPSON HANDLEY, M.S., M.D., Lond., F.R.C.S. Eng., Surgeon to the Middlesex Hospital and to its Cancer Charity. Second edition. Pp. 411 + xvii, illustrated in colour and black and white. 1922. London: John Murray. 30s. net.

IT is sixteen years since Handley's *Carcinoma of the Breast* was first published, and the views then set forth have undoubtedly won widespread acceptance. By the permeation theory of dissemination the author has put the surgical treatment of carcinoma of the breast on a scientific basis. The second edition will be welcomed by all who know Mr. Handley and his work. It has been thoroughly revised, the chapter on the natural process of repair in carcinoma, based on the author's Hunterian lecture on "The Natural Cure of Cancer", has been rewritten, and new chapters on radiological treatment, recurrence and its operative treatment, Paget's disease of the nipple, lymphangioplasty, and injury as a causative factor in carcinoma, have been added.

The author, whilst fully recognizing the importance of comparative experimental methods of research, still lays stress on the value of the study of pathology and morbid anatomy as a means of ascertaining a great deal in relation to cancer and its method of spread. Most of his work has been based on the microscopic study of large areas of tissue taken from the neighbourhood of carcinomatous growths, and the same method has been used in his investigation of Paget's disease and melanotic sarcoma.

The chapters on the radiological treatment of carcinoma of the breast are a valuable help to those who have to deal with this distressing disease, and come at a time when interest in this method of treatment is rapidly gaining adherents, and when definite instructions as to application are to a great extent lacking. The author says that no case of carcinoma of the breast should be treated by *x* rays or radium alone, except under the following conditions: refusal of operation by the patient, old and feeble patients with atrophic cancers, and patients suffering from diabetes or cardiac or renal disease. He is strongly of the opinion that the radiologist should work in conjunction with the surgeon; he should see the case before operation, and note the exact position of the primary growth so that he may irradiate a circle of tissue of about 12 to 14 in. in diameter. with its centre at the position of the growth and not of necessity at the nipple, or the centre of the breast. Special care should be taken to irradiate the approximate position of the microscopic growing edge of the tumour, and extra exposures should be applied to the supraclavicular triangle, anterior mediastinal glands, and lateral chest wall. An *x*-ray exposure before operation, and exposures for three months after, are advocated as a routine. Supraclavicular glands, if enlarged and hard but not fixed, should be removed at the primary operation, but the author now depends more frequently on the insertion of tubes of radium at the time of the operation. He buries one tube in the supraclavicular fossa and one in each of the upper three intercostal spaces close to the edge of the sternum. In this way it is hoped to reduce the recurrences in these areas to the satisfactory figure of 5 per cent, as seen in the skin. The anterior mediastinal glands themselves are but occasionally attacked, and then only when the growth is in the inner quadrant of the breast or when the pectoralis muscle is definitely infected. The only satisfactory method of applying radium is by burying it in the diseased tissues. In many cases especially of supraclavicular glandular enlargement associated with pain due to pressure on the brachial plexus, treatment by the insertion of tubes of radium will frequently relieve the pain, even if the growth be not materially arrested.

Chapter 17 deals with the indications for, and method of performance of, the operation of lymphangioplasty. According to the author 'brawny arm' occurs in one out of every six cases of cancer of the breast. It is due primarily to permeation of the lymphatics and the associated

perilymphatic fibrosis, contributing causes being compression of the axillary vein and obstruction of the lymph channels by growth of emboli in the glands. The operation of lymphangioplasty will relieve most of these cases, but is contra-indicated if the patient is unable to take a general anæsthetic or if the threads will have to pass through cancerous tissues. Details of the operation and records of cases are given.

The chapter on Paget's disease of the nipple is new. The observations and conclusions of Paget, Butlin, and many others are given and discussed. The author's view of Paget's disease is that it is due to permeation of the lymphatics of the nipple by an underlying carcinoma of the breast and that it is always secondary to an underlying carcinoma, though in some cases the latter is so small that it is difficult of demonstration. The disease is not an epithelioma nor is the surface epithelium the seat of malignant change; the changes are inflammatory, and depend upon œdema caused by permeation and fibrosis of the lymphatics. There is an illustration of a large section in a case of Paget's disease, and a coloured picture of a case in a man.

The last chapter on injury as a cause of carcinoma, though interesting, is not convincing. Several cases collected by Coley are shortly described. Coley himself is quoted as saying: "That a single injury may cause a carcinoma as well as a sarcoma is no longer open to speculation". A case is given in some detail where injury was established legally as the cause of a carcinoma of a breast. The author says "If potentially carcinomatous epithelium is already present, injury may let loose this epithelium among connective tissues, and carcinoma may result."

The author's views throughout are clearly put, and his deductions definitely stated. The book is well printed and the illustrations are excellent. The new chapters add greatly to the value of the volume, which is one which can be confidently recommended to all who are interested in this subject.

Le Problème du Cancer. By Wm. Seaman Bainbridge, Professor of Surgery at the New York Polyclinic Medical School and Hospital. Translated into French by Dr. Hertoghe, of Antwerp. Royal 8vo. Pp. 484 + xxiv, with 38 illustrations, and a number of diagrams. 1922. Paris: O. Doin.

This book, already known to many in its original English edition, has proved its value and the force of its appeal by now appearing in the French language. It represents in small compass a complete survey of the problems relating to malignant disease. It begins with a short historical note, which introduces a reference to the modern Institutes devoted to cancer research.

The next section considers the distribution of malignant disease throughout the vegetable and animal kingdom, together with its geographical and ethnological incidence. The main portion of the book is occupied by consideration of the ethnology, histology, experimental observations, clinical course, and treatment of cancer. It concludes with a short reference to the question of placing cases of inoperable cancer in special Homes and the education of the public concerning the problem of cancer.

There can be no doubt that the author has succeeded in bringing together into a very compact form a number of facts relating to the origin and treatment of the disease, in a manner which makes reference to them very easy. The size of the work does not permit of either a full or a critical account of any one part of the subject. It will probably prove of great service as a text-book for those dealing with the general subject of Public Health and kindred social problems.

Cancer: its Cause, Treatment, and Prevention. By A. T. Brand, M.D., Physician, Driffield Poor-Law Infirmary. Demy 8vo. Pp. 120. 1922. London: John Bale, Sons & Danielsson. 8s. 6d. net.

The practice in the wards of a Poor-Law Infirmary is calculated to impress the importance and the hopelessness of the problem of cancer upon the mind of the observer. Dr. Brand, since 1902, has given a number of lectures dealing with the nature and causation of malignant disease, which are put together in the present volume. The author is intensely convinced of the infective and parasitic nature of cancer, and he is eloquent in urging that further attention should be given to the study of treatment, even though this should involve the examination of the claim of many new so-called specific remedies.

Les Tumeurs du Cerveau. By Prof. Viggo Christiansen. French translation by M. Polack, with Preface by Pierre Marie. Pp. 337, with 106 illustrations. 1921. Paris: Masson & Cie. Fr. 25 net.

The subject matter of this book is presented in the form of a series of clinical lectures, and is divided into chapters dealing successively with tumours of the motor region, occipital lobes, base of the brain, base of the skull, pituitary gland, cerebellopontine angle, and cerebellum. There is also an interesting chapter entitled "Diagnostic Incertain". The last section is devoted to surgical treatment, and there follow tables giving some details of cases operated upon, together with a certain amount of information as to the results.

The book is written from the point of view of a physician whose aim is to demonstrate the practical lessons to be derived from a clinical study of his patients; and as regards diagnosis, both of the localization and the nature of the lesions, there is much that is useful and instructive. The author lays stress upon the importance of knowing about the beginnings and the course of development of the symptoms; he emphasizes the need for the most careful neurological examination, but issues a warning against being 'too subtle' in the interpretation of the signs observed. His views upon what he terms 'encysted serous meningitis' are sound, for he recognizes that more or less localized collections of cerebrospinal fluid are not infrequently found in connection with tumours, and he rightly rejects the term 'pseudo-tumour'. In this connection Prof. Pierre Marie remarks in his preface, in characteristic phrase, "Il n'y a pas de pseudo-maladies, il n'y a que des erreurs de diagnostic".

From the surgical point of view the book is disappointing, and contains but little helpful material. The dangers of the two-stage operation are rightly pointed out, and the fundamental importance of operating before symptoms of general pressure have appeared, or at least before they have become pronounced, is fully appreciated. But whilst the author recognizes the fact that radical operations upon the left cerebral hemisphere rarely either produce or aggravate disturbances of speech, he perpetuates the erroneous belief that a simple 'decompression' on the left side is liable to cause such symptoms. Attempts to remove auditory nerve tumours by the translabyrinthine route are rightly condemned, but nothing is said about the intracapsular operation for their removal. Curiously enough, the surgery of pituitary tumours is scarcely mentioned.

The tables of cases operated upon are not very instructive. The first, though entitled "Radical Operation upon 21 Tumours in the Cerebral Hemisphere", contains but 13 cases in which the presence of a tumour was actually verified. It is remarkable that in as many as 6 of these 13 cases papillœdema was absent. One is unfortunately left in doubt as to what is meant by 'radical operation'. The second table contains details of 18 cases of tumour in the posterior fossa, of which 9 were extracerebellar, 5 intracerebellar, 2 intrapontine, and 2 cerebellar cysts.

The results as shown in these tables are not particularly encouraging, and whilst it may perhaps be thought that with tumours of the cerebral hemispheres a percentage of 35 cases in which "not only was life preserved, but for a long while the patients were capable of working" is not to be despised, one can hardly agree that with tumours in the posterior fossa "20 per cent of good results should be considered extraordinarily satisfactory". The number of cases is, however, far too small to permit operative results to be fairly expressed in the form of percentages, and the fact that six different operators were employed detracts still further from the value of any conclusions to be derived from a study of the tables.

The book is one for the general physician, the general practitioner, and the student, rather than for the neurologist or surgeon, and may be regarded as a useful and instructive series of clinical lectures admirably presented.

Infections of the Hand: a Guide to the Surgical Treatment of Acute and Chronic Suppurative Processes in the Fingers, Hand, and Forearm. By ALLEN B. KANAVEL, M.D., Chicago. Fourth edition, thoroughly revised. Medium 8vo. Pp. 500 + viii, with 185 illustrations. 1921. Philadelphia and New York: Lea & Febiger. $5.50.

THE subject of this book is one that commonly does not receive enough attention either in teaching or in practice, though the results following inadequate treatment of an acute infection of the hand may be disastrous to the patient and discreditable to the surgeon. Proper treatment of the condition can only be applied with a thorough understanding of the underlying problems—pathological and anatomical—which are well set out in the book before us. The work has reached its fourth edition, and the previous issues have been noticed in these pages, so that it need not again be reviewed in detail. In the present issue the whole text has been revised in the light of knowledge concerning certain acute infections gained during the war, and a short chapter on the means of restoring function to a disabled hand has been added. The numerous illustrations are excellent, and add greatly to the value of the book.

An Index of Prognosis and End-results of Treatment, By Various Writers. Edited by A. RENDLE SHORT, M.D., B.S., B.Sc., F.R.C.S., Hon. Surgeon Bristol Royal Infirmary, Examiner for first F.R.C.S. Third edition, revised and enlarged. Roy. 8vo. Pp. 594 + xi. 1922. Bristol: John Wright & Sons Ltd. 42s. net.

WE are glad to see another edition of this useful book; it can still be claimed for it that it is unique. We know no other place in which the practitioner or specialist can find without laborious search the statistics and other information which will guide him in advising his patient as to the best line of treatment. This applies particularly to the surgeon. Surgery claims the larger part of this volume, perhaps because the results of operations lend themselves more to statistical study than most methods of treatment. Another great value of such a volume is that successive editions can throw a useful light on the progress of medicine. As the editor points out in the preface to this edition, there is now evidence in such diseases as epithelioma of the lip, strangulated

hernia, and intussusception, that the prognosis is better than at the time of the first edition in 1915.

The second edition of the book had only some results of war experience incorporated in it; the present edition has been thoroughly revised; there is much new matter on ophthalmology, and the sections on venereal diseases and on obstetrics and gynæcology have been rewritten, In the last we should have liked to see a table of the incidence of the complications of pregnancy taken as a whole; it would be of interest to watch for a decreasing mortality in childbirth in later editions. The comparison of medical and surgical treatment in exophthalmic goitre is instructive. We should like to know the evidence for the remarkable statement that acidosis and coma sometimes ensue in renal glycosuria.

Patients often wish to know the prognosis in minor maladies which do not endanger life. We do not think the size of the book need be vastly increased by the inclusion of short notes on some more of these, such as coryza, laryngitis, pharyngitis, whitlow, and various skin diseases. We detected a few minor misprints; and we note that the volume has doubled in price since the first edition.

Anæsthetics in Practice and Theory. By J. BLOMFIELD, O.B.E., M.D. (Cantab.), Senior Anæsthetist to St. George's Hospital, and Lecturer on Anæsthetics to the Medical School. Royal 8vo. Pp. 424 + xii, illustrated. 1922. London: Wm. Heinemann. 25s. net.

IN this interesting volume, the author has contributed a very useful addition to the literature dealing with anæsthetics; it has been well produced, and the subject matter has been most carefully selected and clearly dealt with.

In the introductory chapter Dr. Blomfield reviews the history of the art of administering anæsthetics, and, we are glad to see, has referred to Henry Hill Hickman, the Ludlow surgeon, as a pioneer, which he certainly was, although his work in the beginning of the nineteenth century has not generally received the amount of credit it deserved.

No attempt is made to dogmatize as to the manner in which anæsthetic agents produce their effects; the most commonly accepted theories are described, and the deduction is suggested that the essential factor is "an alteration in the nerve-cells", but no attempt is made to reconcile this view with the fact that single-celled vegetable organisms are capable of being anæsthetized; in fact the question still remains open, and the difficulties which beset it are described in the four chapters dealing with the physiological actions of the more commonly employed drugs. Under this heading modern workers with light anæsthesia will find helpful accounts of the behaviour of reflexes under varying degrees of narcosis, and in different states of health; they will also find important references to the loss of temperature associated with the paralysis of deep narcosis. These chapters on the physiological action of anæsthetic drugs may with advantage be considered in association with the last chapter in the book, which deals with fatalities.

Two hundred and sixty pages are devoted to the details of administration of inhalation anæsthetics, giving the reader full advantage of the author's exceptional experience with the older as well as the newer methods in vogue, without undue bias but with wholesome warnings where necessary, especially in connection with the newer methods such as ether-oil rectal administration and prolonged gas and oxygen. In considering the supposed safety of this latter method, Dr. Blomfield quotes a warning letter written by Gwathmey in 1915, in which the following phrase occurs: "The death was absolutely uncalled for, and has changed my ideas of the safety of nitrous oxide and oxygen entirely. . . . I believe if I had given him ether the man would have been alive to-day".

Anæsthetists will welcome the section dealing with the vexed and difficult question of the preliminary use of narcotic and other drugs, because Dr. Blomfield has given the matter much thought and is able to discuss the pros and cons very clearly. The summary of considerations at the end of the section should serve as a ready guide as to when preliminary drugs are indicated, and when not. Local analgesia and spinal and sacral methods receive careful treatment, with good description of their respective techniques.

We consider that the author has done a good service to the profession by writing this work, and we hope and believe that it will acquire a wide popularity.

Traité de Chirurgie d'Urgence. By FÉLIX LEJARS, Professor of Clinical Surgery in the Medical Faculty, Paris. Eighth edition. In two volumes, revised and enlarged. Royal 8vo. Pp. 1110, 1083 figures, 175 photographs, and 20 plates. 1922. Paris: Masson et Cie. Fr. 90.

IT is hardly necessary to give a long notice to this excellent French text-book, which was published first in 1899, as its appearance in an eighth edition proves that it has been very widely read and appreciated, and, moreover, the English translation by Dickie and Ward is so well known. The last French edition was in 1913, and the present therefore includes the author's ideas of the lessons taught by the war about urgent surgery. In particular, gunshot wounds of the viscera, the treatment of lacerated and contaminated wounds of the soft parts, and the treatment of open fractures

have been revised and added to. One of the chief attractions of the book now, as before, is the careful and beautiful plates and diagrams. It is perhaps doubtful whether the representation of the hands of the operator and his assistant in so many operations adds to or detracts from the value of the pictures, and in any case the naked fingers placed in open wounds, especially in those of joints, is not in conformity with up-to-date technique.

In the section on fractures we think that undue prominence is given to complicated plaster-of-Paris methods and also to details of wire suturing, whilst both plating and pegging are dealt with very inadequately.

But these criticisms affect only minor portions of the work, which as a whole is beyond praise for its careful description and illustration of the problems of urgent surgery. The new English edition is shortly to be issued in one volume.

Jahresbericht über die gesamte Chirurgie und ihre Grenzgebiete, for the year 1920. By PROF. DR. CARL FRANZ, Berlin. Large 8vo. Paper covers. Pp. 886. 1922. Munich: J. F. Bergmann. Berlin: Julius Springer. 53s., English price.

THIS annual review of the surgical literature forms a most valuable book of reference. It gives a short review of the work done in every department of surgery, written by over thirty collaborators, each section being followed by references to literature which, as far as we have been able to test it, are accurate and complete. The only criticism which we have to make is the lateness of its appearance. It deals with the surgery of 1920 and appears in 1922. A double index to subject matter and to authors makes reference very easy.

SHORT NOTES ON BOOKS.

Surgical Diagnosis. [Students' Synopsis Series.] By W. H. C. ROMANIS, F.R.C.S., Assistant Surgeon to St. Thomas's Hospital. Crown 8vo. Pp. 302. 1922. London: J. & A. Churchill. 8s. 6d. net.

A SMALL text-book for students has been written by Mr. Romanis on surgical diagnosis. It is short and clear, and arranged in such a way that reference to any particular point is very easy. A great deal of useful information has been crowded into a small space, and we have not found that accuracy has in any way been sacrificed.

The Clinical Examination of Surgical Cases: a Handbook for Students and Practitioners. By J. RENFREW WHITE, F.R.C.S., Assistant Surgeon, Dunedin Hospital. Crown 8vo. Pp. 129. 1922. Dunedin, N.Z.: J. Wilkie & Co.

ANOTHER small book dealing with the examination of surgical cases comes from New Zealand, and is by Mr. Renfrew White. It consists in a description of the best method of investigation of a number of critical surgical conditions, and is especially designed for the use of students beginning their ward work. Its use by the students responsible for note-taking would tend to produce a more thorough and uniform system of notes in any institution where it is adopted. It is interleaved so that the student may make notes as he goes along.